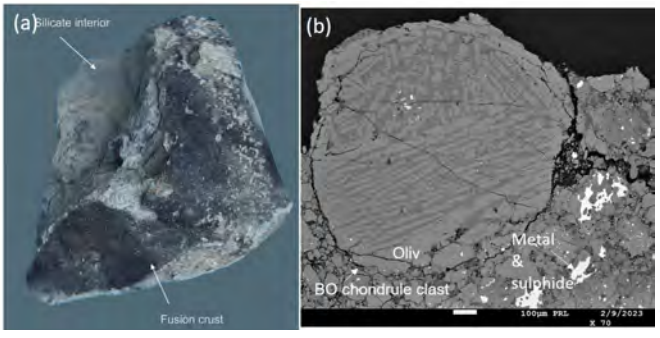
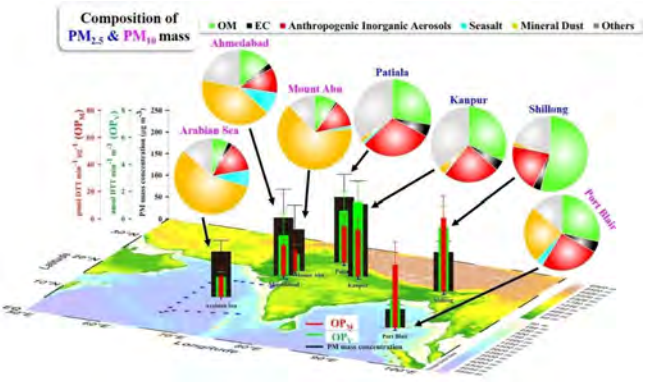
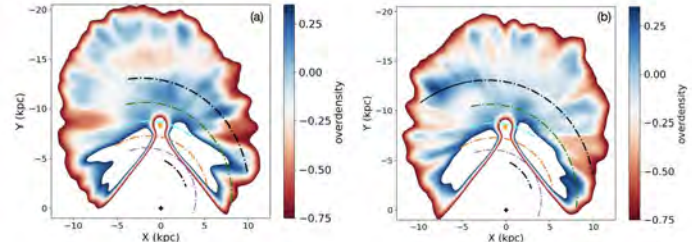
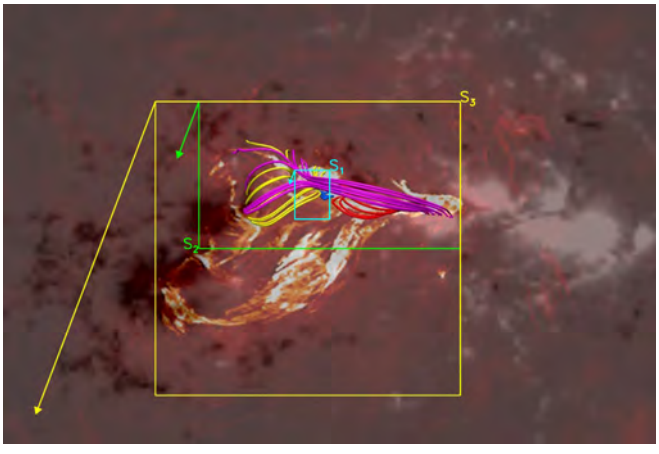
भौतिक अनुसंधान प्रयोगशाला, अहमदाबाद

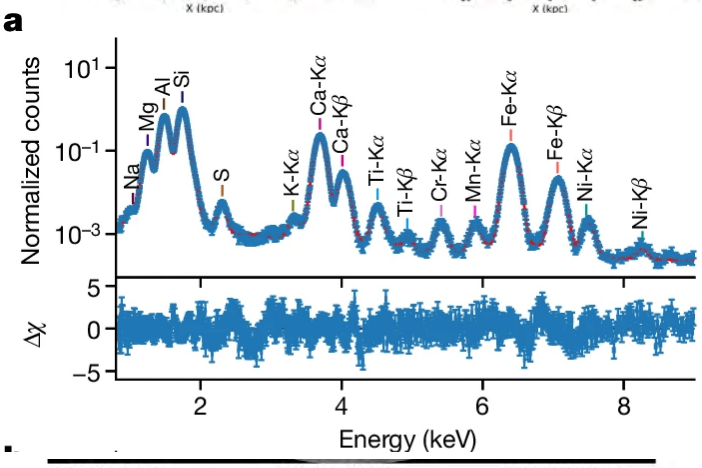
Physical Research Laboratory, Ahmedabad

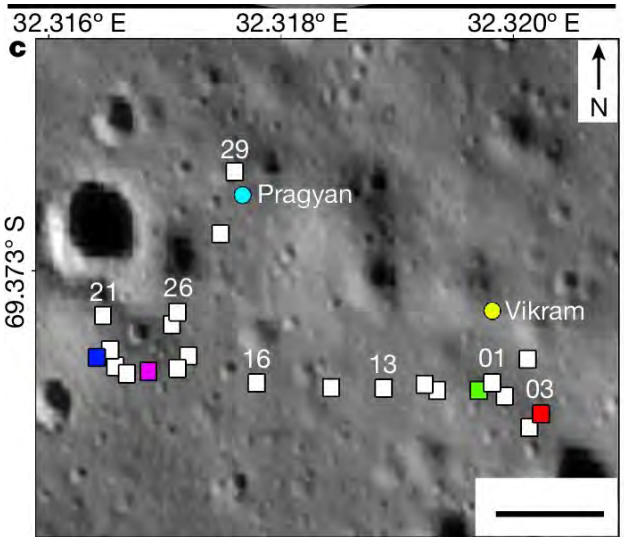


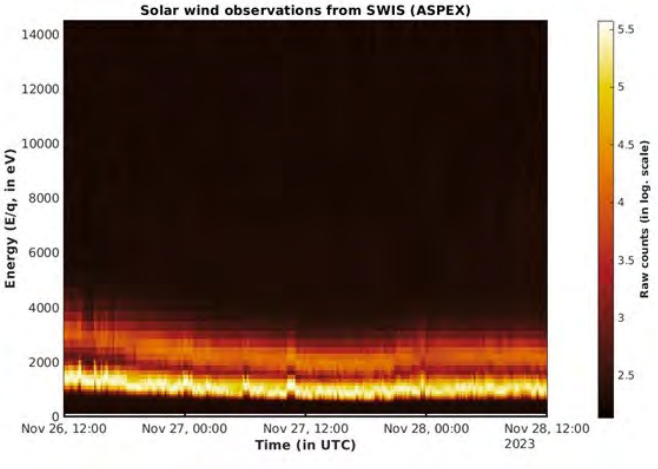












वार्षिक प्रतिवेदन

Annual Report

2023-2024

Front cover page:

Top Left Panel: Hand Specimen of Kopargaon chondrite and BSE image of Barred Olivine chondrule clast

Top Right Panel: The oxidative potential of atmospheric aerosols with the mass concentration and the chemical composition of PM mass over different locations

Middle Left top Panel: Overdensity map of red clump stars: outer spiral arm of the Milky Way

Center Right Panel: Visual representation of reconnection Dynamics and plasma relaxation in MHD Simulation of a Solar Flare

Middle Left down Panel: A sample lunar Spectrum observed by APXS

Bottom Left Panel: Approximate locations of the 23 APXS scientific observation points around the Vikram Lander

Bottom Right Panel: Solar Wind observations from SWIS, ASPEX, a PRL payload onboard Aditya L1

Inside back cover pages: Events at PRL

Back cover page:

PRL's payloads onboard Chandrayaan 3 and Aditya L1, Vikram Lander on surface of the moon, APXS payload on the surface of the moon

PRL campuses

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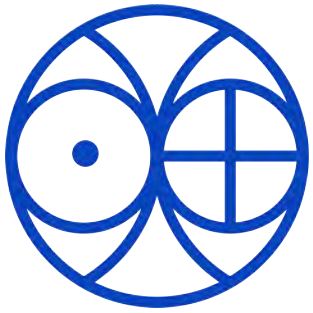
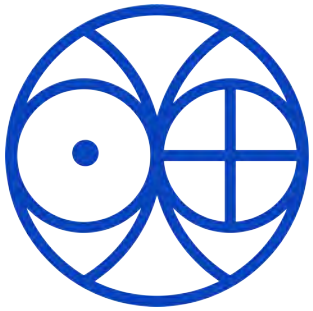


PRL Annual Report

2023 – 2024



PRL research

encompasses

the Earth, the Sun

Immersed in the fields

and radiations

reaching from and to infinity,

all that man’s curiosity

and intellect can reveal

PRL Council of Management

Three nominees of the Government of India

1. Shri A. S. Kiran Kumar Dr. Vikram A Sarabhai Professor, ISRO Antariksh Bhavan, New BEL Road Bengaluru-560231	Chairman
2. Dr. S. Somanath, Secretary, Department of Space, Govt. of India Chairman, ISRO Antariksh Bhavan, New BEL Road Bengaluru-560231	Member
3. (i) Shri M. Maheshwar Rao, IAS Additional Secretary & FA Department of Space, Govt. of India Antariksh Bhavan, New BEL Road Bengaluru-560231	Member (up to 01/01/2024)
3. (ii) Shri Rajiv Kumar Mital Additional Secretary & FA Department of Space, Govt. of India Antariksh Bhavan, New BEL Road Bengaluru-560231	Member (From 02/01/2024)

A nominee of the Karmakshetra Education Foundation

4. Shri Kartikeya V. Sarabhai Director, Centre for Environment Education Ahmedabad-380054	Member

A nominee of the Ahmedabad Education Society

5. Shri Sanjay S. Lalbhai Chancellor & Chairman, Board of Governors, Ahmedabad University, Ahmedabad-380009	Member

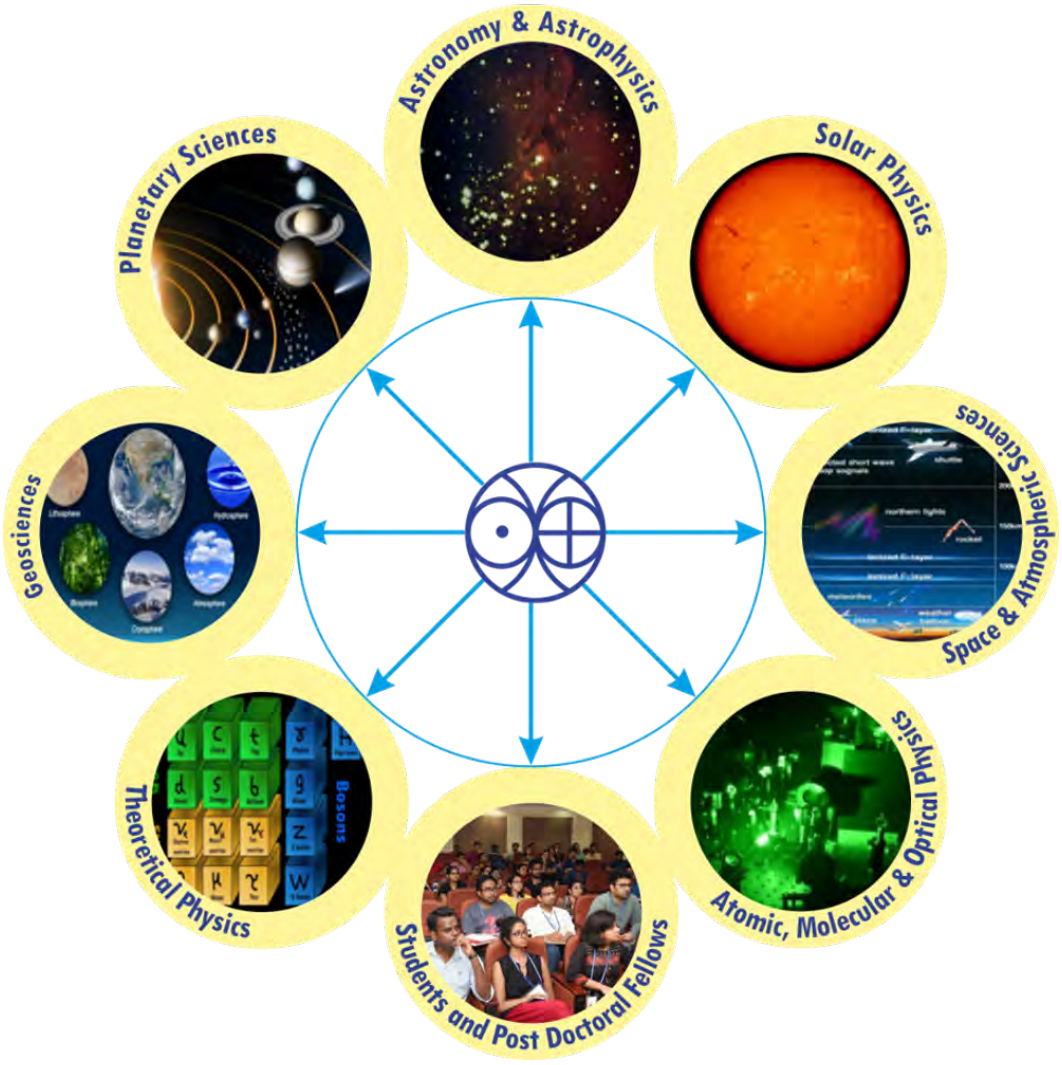
A nominee of the Govt. of Gujarat, Gandhinagar

6. (i) Shri S.J Haider, IAS The Principal Secretary (ii) Shri Mukesh Kumar, IAS The Principal Secretary Education Dept. (Higher & Technical Education) Government of Gujarat, Gandhinagar	Member (up to 12/07/2023) Member (From 13/07/2023)

Physical Research Laboratory, Ahmedabad

7. Prof. Anil Bhardwaj, Distinguished Professor & Director	Member (Ex-Officio)
8. Prof. R. D. Deshpande, Senior Professor & Registrar (From 01.01.2023)	Member - Secretary (Ex-Officio)
9. Eminent Scientist / Academician	Vacant

Areas of Scientific Research and Activities



Contents

From The Director's Desk

The year 2023 was scientifically enriching and eventful for PRL. Along with ISRO, the dedicated efforts of PRL scientists resulted in ground-breaking results from the PRL's experiments on Vikram lander and Pragyaan rover on Chandrayaan-3 mission after the flawless display of professionalism and prowess by ISRO that resulted in the successful landing of the Vikram Lander and deployment of the Pragyaan rover in August 2023.

Over the last year, PRL has published nearly two hundred sixty research papers in high-impact peer-reviewed journals and 23 PhD theses, apart from obtaining significant results from the Chandrayaan-3 Lander and Rover mission and the Aditya-L1 mission. The level of commitment displayed by the PRL faculty and staff in carrying out high quality research, producing excellent space-borne experiments, in-house instrumentation development, detailed laboratory analysis, and intense academic and scientific programs has been exemplary. These efforts have been recognized through coveted awards and honours. PRL research scholars have received best paper awards for presenting their research work in national and international scientific conferences, and some have also won the best thesis awards. PRL faculty have received more than two hundred and forty invitations to deliver invited talks and lectures at conferences, symposia, workshops, and academic and research institutions. The commitment and diligence shown by the talented faculty and staff of PRL is a matter of great satisfaction and pride for me.

Several new and vital scientific findings were obtained during 2023—2024, some of which are briefed below:

PRL's observational findings based on the infrared images showed that the cloud G11.11-0.12 or 'Snake' nebula (distance $\sim$2.92 kpc; length $\sim$27 pc) is one of the most uncommon sites which is home to a multiple infrared-dark hub-filament system candidates (extent $<$6 pc), where massive clumps and signs of intense star formation (i.e. outflows, protostars, and masers) are found. For the first time, PRL study suggest that the site 'Snake' nebula is expected to become one of the intense Galactic star-forming sites in the future.

The 3-D distribution of the red clump stars was studied using the newly constructed catalogue to unveil the outer structure of the disk of the Milky Way. The analyses reveal that the scale height of the Galactic disk is not constant but increases with Galactocentric distance, i.e., representing a flared disk. Additionally, an S-shaped warping is observed in the disk, portraying the bending of the disk upwards in one part and downwards in the other part of the Galaxy. The comparison of the detected warp height and flare strength in the outer regions of the Galactic disk from the Red Clump (RC) stars with those seen in the younger population presents strong constraints on the Galaxy evolution models.

For the first time, Seven peculiar narrow-line Seyfert-1 galaxies (NLS1s) are studied for the presence of Intra-night optical variability (INOV), which show recurring flaring at 37 GHz, indicating the presence of relativistic jets in them. Using PRL's 1.2m and 2.5m telescopes at Mt. Abu and 1.04m and 1.3m telescopes at Nainital, scientists at PRL performed photometric monitoring observations of these NLS1s, and showed optical variability on the time scales of a few hours. Thus, INOV characteristics of seven NLS1s favour the presence of relativistic jets in them, and that NLS1s, a subclass of AGN, host relatively less massive black holes ($10^6 \mathrm{M}_e$) and can also launch relativistic jets.

Cadmium Zinc Telluride Imager (CZTI) onboard India's AstroSat, reported around 24% polarized high energy X-rays with a very high detection significance in 100–380 keV, which is also increasing with energy. These results strongly suggest that the mechanism of X-ray emission is more energetic than 200 keV from the jet, possibly synchrotron radiation in an ordered magnetic field. Moreover, the CZTI detected high X-ray polarization only in the state that exhibits strong radio emission from the jet. This confirms the direct connection of the hard X-ray emission to the relativistic jet in the source for the first time.

To investigate the propagation characteristics of the solar atmospheric gravity waves, PRL scientists constructed two height cross-spectra and studied phase and coherence signals in the wavenumber-frequency dispersion diagrams and their association with background magnetic fields. The results provide observational

evidence to the earlier numerical simulations, suggesting that gravity waves are suppressed or scattered and reflected back into the lower solar atmosphere in magnetic fields. This illustrates that the dynamics of gravity waves in the solar atmosphere are affected by background magnetic fields.

Using GRAIL data, the late-phase volcanism in the Australe North Basin (35.5 $^{\circ}$S, 96 $^{\circ}$E) of $\sim$1.7 Ga has been discovered on the Moon. The basin is completely obliterated and could be the oldest impact structure on the Moon, recently revealed.

The most recent meteorite 'fall' in India, as per Meteorological Bulletin database, was witnessed on 24 January 2023 at 06:30 IST in Kopargaon taluka of Ahmednagar district, Maharashtra. The collected mass of the meteorite fragments was about $\sim$1 kg. The rocky meteorite is classified as LL-group ordinary chondrite of petrologic type-5. The spectral resemblance of the Kopargaon LL chondrite suggests that it could be the fragmental breccia of an S-type asteroid probed by the Hayabusa-1 mission.

Alpha particle-induced X-ray spectroscopy (APXS) detected characteristic X-ray lines emitted by atoms excited by incident alpha particles and X-ray radiation. A novel method for estimating the anticipated APXS signals from prominent K $_{\alpha}$ lines for various lunar compositions (KREEP basalt and FAN considered here) are presented. All the major elements of K $_{\alpha}$ lines are well above the background for the high Al basalt composition, except for the Na K $_{\alpha}$ line. Modelling results suggest that an alpha-induced X-ray spectrometer on a lunar rover can detect K $_{\alpha}$ lines of major elements and can distinguish different lunar compositions.

Study by PRL scientists has revealed that the aerosol radiative forcing efficiency (ARFE) in the atmosphere is significantly high over the Indo-Gangatic Plains (IGP) and the foothills of the Himalayas (80-135 Wm $^{-2}$ per unit aerosol optical depth (AOD)), with values greater at higher Himalayas elevations. The mean ARFE over the Himalayas is 2-4 times higher than polluted sites in South and East Asia, because of higher AOD and aerosol absorption (lower SSA). Further, the observed annual mean aerosol heating rates (0.5-0.8 K/day) are significantly higher than those previously reported values, implying that the aerosols alone could account for more than 50% of the total warming (aerosols + greenhouse gases) of the lower atmosphere and surface over this region.

A ship-campaign based in-situ measurements of key Non-Methane HydroCarbons (NMHCs) were made over the Arabian Sea in winter 2018 to characterize the impact of South Asian outflow and the role of oceanic sources. Various sources, such as anthropogenic emissions from the Indian subcontinent, oceanic emissions, biogenic emissions from the Western Ghats, and shipping lane emissions, contributed to the observed NMHCs concentrations. However, marine sources dominated the measurements in the remote regions. With their diverse sources, volatile organic compounds (VOCs) influence the atmospheric chemistry and radiative balance over coastal and remote marine environments. Interestingly, the levels of NMHCs measured in this study are much higher than those measured about two decades ago during the INDOEX campaign.

By employing high spectral resolution measurement, PRL scientists have made the first observations of the daytime Stable Auroral Red (SAR) arcs. As the SAR arcs are caused by the enhancement of electron temperature in the ionosphere during space weather events, detailed investigations carried out by the process of forward modelling enabled estimation of the magnitudes of electron the temperatures to be in the range of 3500-4400 K. Such results during the daytime open up new possibilities of investigating the underlying mechanisms of magnetosphere-ionosphere coupling that are operative during space weather events in the daytime.

Stream Interface Regions (SIRs) in the solar wind have the potential to cause severe space weather disturbances on Earth. To understand the changes in the alpha-proton ratio (A $_{He}$) in the SIRs, events during solar cycles 23 and 24 are investigated. It is shown that alpha populations are enhanced at higher bulk velocity angles, particularly in the fast wind regions of SIRs, enhancing A $_{He}$. This investigation highlight the importance of bulk velocity angle and differential velocity in the fast wind region for the changes in A $_{He}$ in SIRs.

Carbon dioxide (CO $_2$) and methane (CH $_4$) are the most important greenhouse gases that cause global warming. In a laboratory experiment, a significant release of CO $_2$ and CH $_4$ was observed from the photochemical degradation of plastics. This finding indicates that the proper accounting of greenhouse gases (CO $_2$, CH $_4$) is necessary while studying the effects of plastics on our climate and the biogeochemical cycling of carbon in terrestrial and aquatic systems.

The blocking temperature of marble, calcite, and dolomite cooling rates have been estimated using carbonate-clumped isotope thermometry. This has important implications for estimating the exhumation rates and understanding the mountain-building process.

PRL scientists assessed the Joshimath crisis at the local people's request to identify the zones and probable causes of subsidence, based on which a report was submitted to the regional administration for perusal, and a scientific paper on this report was published in Current Science, 2023. The National Green Tribunal (NGT) took cognizance of the article published by PRL scientists in Current Science that suggests the need to declare the Higher Himalaya an eco-sensitive zone, and issued a suo moto notice for evaluation.

Scientists of PRL have determined Holocene slip rates along the Himalayan Frontal Thrust in the western Himalayan Nahan salient. It is essential to consider seismic hazards in the region. The work suggests a seismic quiescence of 600–700a, resulting in a $\sim$ 6.2–8.5 m slip deficit on the HFT. This could trigger a Mw $\geq$ 7.7 earthquake in the region.

Using the phenomena like how Earth's path around the Sun changes slightly (perihelion precession), how light bends around massive objects (gravitational light bending), and delays in signals passing through gravitational fields (Shapiro time delay) constraints were obtained on a new type of extended range force called the monopole-dipole force acting between polarized and unpolarised objects.

Using a liquid Argon-based neutrino detector, it was shown how the combination of beam and atmospheric neutrinos can help in resolving the ambiguity in determining the octant of the neutrino mixing angle involved in governing the flavour change of neutrinos coming from these sources in the presence of an additional sterile neutrino.

Rigorous characterization of the mean photon number per pulse employing multiple detectors enabled the detection of adversarial attacks and the estimation of secure key rates more precisely, thus

strengthening the overall security of the quantum key distribution (QKD) system.

High-accuracy calculations of the states' isotope shift (IS) factors involving the D1 and D2 lines in Zn II were performed using analytical response relativistic coupled-cluster theory. These radii were compared with the ones inferred from muonic x-ray measurements. The study revealed that in cases where the many-body atomic calculations of IS factors are well established, the optical determinations of differential radii were more reliable than those from the muonic x-ray measurements, which opens the door to obtaining more trustworthy nuclear radii across the nuclear chart.

PRL Scientists have demonstrated quantum sensing using single photons at a near-video frame rate. Typically, using single photons makes the high-resolution quantum sensing a slow process. However, by finding a trade-off between the spectral width of the single photons and the rate of the single photon generation by optimizing the length of the nonlinear crystal, the high-speed quantum sensing measurements with high resolution is experimentally shown.

Scientists at PRL developed an optical mirror whose transmission and reflection can be controlled dynamically without changing the experimental setup. By exploring the Pancharatnam–Berry phase in a Sagnac resonator, the mirror with transmission varying from 0-100% was demonstrated.

The study of the morphology and stability of 1 & 2 Cyanonaphthalene – a Polycyclic Aromatic Hydrocarbons (PAHs) molecule conducted in PRL shows that this PAH molecule can remain stable in an amorphous state even at relatively higher temperatures of 250 K than previously known. This implies that PAHs can be present in icy mantles at high temperatures and potentially participate in further chemical reactions under the low temperatures and pressure found in space.

The ASPEX experiment onboard Aditya-L1 mission which was launched on 2 September 2023, made magnetospheric measurements during October 2023, first ever from any of the Indian satellite missions, on its way to the Langrange point-1. Several exciting results, both of magnetospheric and solar wind science, have emerged and these are under preparation for communication to peer reviewed journals.

PRL continues to be firmly committed to the popularization of Science. In this endeavour, PRL celebrated National Science Day (NSD) 2024 in two phases. In the Phase 1, PRL's members visited 21 different centres across Gujarat and conducted a screening test for the Aruna Lal Scholarship on 21 January 2024, wherein 169 schools were covered. Close to 1500 students participated with about 50% being girl students. In addition to the Scholarship tests, the PRL team demonstrated science experiments through its signature program, the Science Express. In Phase 2 of the NSD, the students shortlisted from the screening exam were invited to PRL on Wednesday, 06 March 2024. About 150 students and 60 teachers/accompanying parents visited PRL on 6 March; interviews for the Aruna Lal scholarship were also held on this day. Furthermore, the Vikram Sarabhai Protsahan Yojana (VIKAS) Scholarship exam was also conducted at 21 different centres in Gujarat on 21 January 2024.

The National Space Science Exhibition 2024 was conducted at Goa University as a part of National Space Science Symposium (NSSS) 2024 duing February 26–March 01. PRL showcased its research areas and encouraged, especially the student visitors, to take up sciences as their career. PRL was invited to participate in the Academic-Industry meet, CoLAB 2024, organised by the IIT Gandhinagar on 02 March 2024. PRL researchers put up stall and exhibits in this event to engage with the industry partners who were participating in this event.

Towards the responsibility of capacity building in niche areas in the country, PRL continues to provide highly skilled researchers through its vibrant Doctoral and Post-Doctoral programmes. In addition, PRL conducts a Visiting Scientist programme for university teachers and project training for graduate and post-graduate students in engineering and Science to conduct short- and long-term project work. PRL organizes intensive summer programmes for students and college and university teachers every year and also partakes through its association with similar programmes conducted by the Indian Science Academies. Through these programs, more than 100 students were trained. PRL continues its strong academic association with universities and institutes in Gujarat and nationwide.

This year, PRL organized several national and international conferences and workshops covering almost all the areas of research in PRL. These include the 1^{st} Workshop on Space Weather Science and Opportunities, 2^{nd} Indian Space Weather Conference (ISWC); ISRO Structured Training Program (STP) 2023; 3^{rd} Venus Science Conference; 8^{th} Students Conference in Optics and Photonics (SCOP-2023); 3^{rd} Meteoroids, Meteors and Meteorites: Messenger from Space (MetMESS-2023); the 1^{st} VIKRAM Discussion on Astrochemistry and Astrobiology, International Conference on Planets, Exoplanets and Habitability (ICPEH); 9^{th} Topical Conference On Ultrafast Photonics And Quantum Science; 5^{th} Workshop on Luminescence Dating and its Applications; Short Course on Isotopes in Nature; 4^{th} workshop of International Network in Space Quantum Technologies (INSQT). All these events contribute to capacity building in various specialized science fields in the country.

PRL hosted the 4^{th} Arvind Bhatnagar Memorial Lecture, the 4^{th} Bibha Chowdhuri Memorial Lecture, and the 6^{th} PRL-Indian Association of Physics Teachers (IAPT) Vikram Sarabhai Lecture.

PRL ensures the use of Hindi in all administration and official communications and takes adequate steps. The website of PRL is bilingual. The work done at PRL in implementing Hindi in various domains has been recognized by the Town Official Language Committee through an award for best work in Hindi consecutively for last two years, as well as by DOS, and the Parliamentary Committee on Hindi during their evolution of progress of work in Hindi in PRL.

I am indebted to all the members of PRL Council of Management for their constant encouragement, invaluable advice, and wholehearted support for all the scientific activities pursued at PRL. In particular, I am grateful to Shri A. S. Kiran Kumar, Chairman, PRL Council, and Dr. S. Somanath, Chairman, ISRO and Secretary Department of Space, for their sage advice, unstinted support and encouragement.

Anil Bhardwaj
Director

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Science Highlights

Astronomy and Astrophysics

- Comets, as remnants of the proto-planetary disk, hold valuable information about the early Solar system. This study focuses on the analysis of four comets, namely 46P, 38P, 41P, and C/2015 V2, using High-resolution Echelle Spectrograph (HESP) observations on the Himalayan Chandra Telescope (HCT). These observations revealed distinct emission lines in various molecular bands of the comets. Analysis of the emission strengths along the comets' orbits showcased variations, providing insights into the composition and evolution of these icy bodies. The study successfully resolved the green and red doublet forbidden oxygen lines in comets C/2015 V2, 46P, and 41P, enabling the computation of intensities and intrinsic line velocities for further analysis. By determining the Ortho-to-Para-Ratio of NH_3 (Ammonia) and Green-to-Red Doublet ratio in comet 46P and highlighting the significance of detailed modeling techniques, the study sets the stage for future research on cometary studies, offering valuable details of the early history and composition of the Solar system's building blocks.

- The relative importance of magnetic fields, turbulence, and gravity in the early phases of star formation is still not well understood, because magnetic fields are very difficult to measure. Using high-resolution dust polarization observations at 850 μm, the early phases of star formation in the filamentary hub of the molecular cloud, G148.24+00.41, is carried out. The magnetic field strength of the cluster forming clump, located in the hub, is found to be 24.0 $\pm$ 6.0 μG. From the energy budget, mass-to-flux ratio, and virial analysis, it is found that at the hub of G148.24+00.41, the gravitational energy has an edge over magnetic and turbulence generated kinetic energies. Therefore, even though a stellar cluster has formed in the clump, gravity still has an upper-hand, thus, the clump will continue to form stars. This study highlights that the hub filamentary system is an ideal place for making massive and richer clusters.

- The "Pillars of Creation" or "elephant trunks" in the Eagle Nebula (M16; distance $\sim$1.74 pc) has been regarded as a site of active star formation. To probe the star formation processes, high-resolution and high-sensitivity near-infrared and mid-infrared data (resolution $\sim$0.07–0.7 arcsec) from the James Webb Space Telescope (JWST) are employed toward the Pillar IV and an ionized knot HH 216 in M16. Pillar IV is known to host a Class I protostar that drives a bipolar outflow. The ionized knot HH 216 is undetected with molecular hydrogen emission at 4.693 μm. High-resolution images reveal entangled ionized structures (below 3000 AU) of HH 216. The JWST images reveal the protostar as a single, isolated object (below 1000 AU). New knots in molecular hydrogen emission at 4.693 μm are detected and are mainly found on Pillar IV's northern side. This particular result supports the previously proposed episodic accretion in the powering source of HH 216.

- It is thought that a hub-filament system, which is a junction of filaments, is considered as the potential site of massive star formation. Such systems are very important targets to study the mechanism of mass accumulation in massive star formation. Previously published works show that a single hub-filament system, whether it is small-scale or large-scale, is commonly investigated in star-forming regions. For the first time, our observational findings based on the infrared images show that the cloud G11.11-0.12 or 'Snake' nebula (distance $\sim$2.92 kpc; length $\sim$27 pc) is one of the most uncommon sites that is home to multiple infrared-dark hub-filament system candidates (extent $<$ 6 pc), where massive clumps and signs of intense star formation (i.e. outflows, protostars, and masers) are found. Based on the existing literature, it is still a matter of debate how many hub-filament systems are present in a given star-forming site or a filamentary cloud. Overall, the observed outcomes suggest that the site 'Snake' nebula is expected to become one of the intense Galactic star-forming sites in the future.

- Nearby ($\sim$1.5 kpc) massive star-forming sites AFGL 5180 and AFGL 6366S are studied using multi-wavelength data sets. These sites are located at opposite edges of a filamentary molecular cloud as traced using the ^{13}CO(J=1-0) line data. Each site hosts the Class II 6.7 GHz methanol maser emission, which has been known as the signatures of the early stages of massive star formation. Using the Herschel 160 μm dust continuum image, a hub-filament system is investigated toward both the sites. Using the ^{13}CO(J=1-0) line data, reliable signatures of the cloud-cloud collision of two cloud components at [$-$3.1, 4.8] and [5.8, 12.9] km s^{-1} have been investigated toward the selected target sites. The collision event took place about 1 million years ago, and seems to be responsible for the formation of hub-filament systems and the massive stars toward both the target sites.

- A group of stars that are gravitationally bound to one another is called a star cluster, however, their formation is not well understood. Using observations of CO(1-0) isotopologues, this work explored the gas kinematics and dynamics of the cluster forming molecular cloud G148.24+00.41 and found that the cluster forming clumps are located at the nexus of the filamentary flows. From the gas kinematics and estimated accretion rate of the filamentary flows, the study postulates that large-scale river-like filamentary accretion flows towards the central region of a collapsing cloud is likely an important mechanism for supplying the matter necessary to form massive clumps and subsequent stellar clusters.

- Understanding the structure and formation of our Milky Way galaxy is one of the key goals in the field of Galactic astronomy. However, our vantage point within the Galaxy presents challenges in mapping its complete structure. While

it is well known that our galaxy is a barred spiral galaxy, the finer details, such as the number and position of arms, remain subjects of ongoing debate. The galactic disk was mapped in more detail by studying the distribution of red clump stars, an indicator of the intermediate-to-old age population. A sample of red clump stars ($\sim$ 8.8 Million stars - the largest to date) were extracted utilizing the 2MASS and Gaia data in the Galactic disc covering 40 deg $\leq$ l $\leq$ 340 deg and $-$10 deg $\leq$ b $\leq$ +10 deg. The resulting distribution of red clump stars in the Galactic plane reveals the poorly constrained Outer arm of the Galaxy, extending over 6 kpc beyond prior estimations. This study provides the first direct observational evidence of the warping of the spiral arms as depicted by the red clump stars.

- The 3D distribution of the red clump stars were studied, using the newly constructed catalog, to unveil the outer structure of the disk of the Milky Way. The analyses reveal that the scale height of the Galactic disk is not constant but increases with Galactocentric distance, i.e., representing a flared disk. Additionally, an S-shaped warping is observed in the disk, portraying the bending of the disk upwards in one part and downwards in the other part of the Galaxy. The comparison of the detected warp height and flare strength in the outer regions of the Galactic disk from the Red Clump (RC) stars with those seen in the younger population presents strong constraints on the Galaxy evolution models.
- The formation of carbon monoxide and dust is detected in the ejecta of recurrent nova V745 Sco after 8-10 days from the outburst. This is the first-ever detection of dust and carbon monoxide molecule in the ejecta of a recurrent nova. The mass, temperature and velocities of carbon monoxide and dust was estimated. The physical conditions of the ejecta appear to be harsh to form molecules and dust. The possible sites of the formation of dust and molecules are proposed.
- A comprehensive study of Be/X-ray binary pulsar SMC X-2 during the 2015 and 2022 outbursts, reveals the uniqueness and strong luminosity dependent of its pulse profile. It evolves from a broad-humped into a double-peaked profile above a luminosity of 3 $\times$ 10^{38} erg s^{-1}. The spectral evolution of the pulsar during the 2022 outburst is also investigated using NICER observations. The power-law photon index shows a negative and positive correlation below and above the critical luminosity, respectively, suggesting evidence of spectral transition from the subcritical to supercritical regime. The broad-band spectra of four sets of NuSTAR and XRT/NICER observations can be described using a cut-off power-law model with a blackbody component. An absorption-like feature at 29.5 keV, known as cyclotron resonance scattering feature, is detected in the spectrum during the 2015 outburst. The observed cyclotron line energy variation is explored in terms of accretion induced screening mechanism or geometrical variation in line forming region.
- The first Galactic ultraluminous X-ray pulsar Swift J0243.6+6124 has been observed with NICER during its giant and normal X-ray outbursts between 2017 and 2023. Temporal analysis of the data shows a distinct break in the power density spectra of the source. Corresponding break frequency and slopes of the power-laws around the break vary with luminosity, indicating a change in the accretion dynamics with the mass accretion rate. Interestingly, quasi-periodic oscillations are detected within a specific luminosity range, providing further insights into the underlying physical processes. Spectral analysis of data during the giant and all normal outbursts reveal a double transition in the evolution of continuum parameters like the photon index and cutoff energy at luminosities of 7.5 $\times$ 10^{37} and 2.1 $\times$ 10^{38} erg s^{-1}. This indicates three distinct accretion modes experienced by the source, mainly during the giant X-ray outburst. A soft blackbody component with a temperature of 0.08–0.7 keV is also detected in the spectra. The observed temperature undergoes a discontinuous transition when the pulsar evolves from a sub- to super-Eddington state. Notably, in addition to an evolving 6–7 keV iron line complex, an 1 keV emission line is observed during the super-Eddington state of the source, implying X-ray reflection from the accretion disk or outflow material.
- A long-term X-ray study of a nearby Active Galactic Nucleus Mrk 6 is carried out by utilising observations from XMM-Newton, Suzaku, Swift, and NuSTAR observatories, spanning 22 years from 2001 to 2022. From timing analysis, variance, normalised variance, and fractional rms amplitude are estimated in different energy bands. The temporal study shows fractional rms amplitude below 10% for the shorter time-scale ($\sim$60 ks) and above 20% for the longer time-scale (weeks). A complex correlation is observed between the soft (0.5–3.0 keV) and hard (3.0–10.0 keV) X-ray bands of different epochs of observations. This result prompts a detailed investigation through spectral analysis, employing various phenomenological and physical models on the X-ray spectra. The spectral analysis reveals a heterogeneous structure of the obscuring material surrounding Mrk 6. From this study, it is suggested that a partially ionized absorber exhibits a rapid change in location and extends up to the narrow-line regions or torus. In contrast, another component, located far from the central engine, remained relatively stable. During the observation period, the source luminosity in the 3.0–10.0 keV range varies between (3–15) $\times$ 10^{42} erg s^{-1}.
- Active Galactic Nuclei (AGN) powered by accretion onto supermassive black holes (SMBH) show flux variability across the entire electromagnetic spectrum. The cause of variability can be attributed to changes occurring in accretion disk and outflowing jet. Therefore, variability studies of AGN can be used as diagnostic tools to understand the physical processes occurring in the inner regions of AGN. Intra-night optical variability (INOV) is studied, for the first time, for a sample of seven peculiar narrow-line Seyfert 1 galaxies (NLS1s) which show recurring flaring at 37 GHz indicating the presence of relativistic jets in them. However, no indications of relativistic jets are found in 1.6 GHz, 5.2 GHz, and 9.0 GHz radio observations. Using 1.2m, 2.5m telescopes at Mt. Abu and 1.04m, 1.3m telescopes at Nainital we performed photometric monitoring observations of these NLS1s and found them to show optical variability on the time scales of a few hours aka INOV. The duty cycle (frequency of occurrence) of INOV in this sample is similar to that of those NLS1s and AGN which possess relativistic jets. Thus, INOV characteristics of our NLS1s favour the presence of relativistic jets in them and it appears that NLS1s, a subclass of AGN, hosting relatively less massive black holes (10^6 $M_\odot$) can also launch relativistic jets.
- The circumnuclear material around active galactic nuclei (AGN) is one of the essential components. However, our understanding of the circumnuclear material in terms of its geometrical shape, structure, and its dependence on accretion rate is still debated. To probe the nature and geometry of

circumnuclear material around AGN we performed multi-epoch broad-band X-ray spectral modelling of the AGN hosted in Circinus galaxy. We utilised Chandra and XMM-Newton X-ray observations and all the available hard X-ray (>10 keV) observations from different telescopes (BeppoSAX, Suzaku, NuSTAR, and AstroSat) taken at ten different epochs across 22 years from 1998 to 2020. The broad-band X-ray spectral modeling of AGN suggests the presence of obscuring material having toroidal geometry around AGN. We find that obscuring torus is nearly edge-on and it has a low covering factor of only 28%. The line-of-sight column densities are high ($N_{H,LOS}$ = 4.13–9.26 $\times$ 10^{24} cm^{-2}) in all the epochs. Our study reveals variable line-of-sight column density on all time-scales ranging from one day to one week to a few years, suggesting a clumpy circumnuclear material located at sub-parsec to tens of parsec scales.

- The soft excess, an excess emission below 2 keV, is an extraordinary feature in the X-ray spectra for most of the Seyfert 1 AGNs. The origin of soft excess is one of the major open questions in AGN research even about four decades after its discovery. The presence/absence of this feature in a sample of 21 "bare" Seyfert 1 AGNs, a subclass of Seyfert 1 galaxies, with intrinsic absorption column density (NH) $\sim$ 10^{20} cm $^{-2}$, in the local Universe (z $<$ 0.2) is investigated using XMM-Newton and Swift/XRT observations. The luminosities of the primary continuum, the X-ray emission in the 3–10 keV energy range, and the soft excess - the excess emission that appears above the low-energy extrapolation of the power-law fit of 3–10 keV X-ray spectra - are calculated. Our spectral analysis reveals that the long-term intrinsic luminosities of the soft excess and the primary continuum are tightly correlated. We also found that the luminosities are correlated for each source. This result suggests that both the primary continuum and soft excess emissions exhibit a dependency on the accretion rate in a similar way.

- Broad-band spectral and timing analysis of a flaring event of $\sim$120 ks duration in the narrow-line Seyfert 1 galaxy NGC 4051 was carried out using simultaneous XMM-Newton and NuSTAR observations. The 300 ks NuSTAR observation and the overlapping XMM-Newton exposure were segregated into pre-flare, flare, and post-flare segments. During the flare, the NuSTAR count rate peaked at 2.5 times the mean count rate before the flare. Using various physical and phenomenological models, the 0.3–50 keV X-ray spectrum is found to consist of a primary continuum, reprocessed emission, warm absorber and ultra-fast outflows at different time-scales. The mass of the central black hole is estimated to be $>$1.32 $\times$ 10^5 solar-mass. The absence of correlation between the flux in the 6–7 keV and 10–50 keV bands suggests different origins of the iron emission line and the Compton hump. We found that the reflection fraction drops significantly during the flare, accompanied by an increase in the coronal height above the disc. After the alleviation of the flare, the coronal height drops and the corona heats up. This indicates that there could be inflation of the corona during the flare. We found no significant change in the inner accretion disc or the seed photon temperature. These results suggest that the flaring event occurred due to a change in coronal properties rather than any notable change in the accretion disc.

- Cadmium Zinc Telluride Imager (CZTI) on board India's first Astronomical satellite AstroSat, reported around 24% polarized high energy X-rays with a very high detection significance in 100–380 keV which is also increasing with energy. These results strongly suggest that the mechanism of X-ray emission more energetic than 200 keV is from the jet, possibly synchrotron radiation in an ordered magnetic field. Moreover, the CZTI detected high X-ray polarization only in the state that exhibits strong radio emission from the jet. For the first time, therefore, one can confirm the direct connection of the hard X-ray emission to the relativistic jet in the source.

- From a study of dipole asymmetries in the sky distribution of radio galaxies in surveys comprising millions of radio sources, it has been found that the amplitudes of radio source dipoles are significantly larger than that of the cosmic microwave background dipole. This is inconsistent with the cosmological principle, the basis of modern cosmology.

Solar Physics

- The solar chromosphere serves as an important conduit for mass and energy between the dense, 6000 K photosphere and the tenuous, million degree corona. The solar chromosphere has a complex magnetic structure, where the plasma beta changes dramatically. Determining the processes that maintain the thermal structure of the solar atmosphere is one of the fundamental problems in solar physics. In this study we attempt to ascertain the source of sustained heating over several days in the chromosphere and transition region above a sunspot light bridge (LB) by combining observations from the Multi-Application Solar Telescope (MAST), the Interface Region Imaging Spectrograph (IRIS), Hinode, the Atmospheric Imaging Assembly (AIA), and the Helioseismic and Magnetic Imager (HMI). At the photosphere, the LB exhibits a granular morphology with field strengths of about 400 G and no significant electric currents. The sunspot does not fragment, and the LB remains stable for several days. The chromospheric temperature, IRIS line intensities and widths, and AIA 171 and 211 Å intensities are all enhanced in the LB with temperatures from 8000 K to 2.5 MK, that follow the underlying photospheric morphology. Photospheric plasma motions remain small, while the chromosphere and transition region indicate predominantly redshifts of 5-20 km/s with occasional supersonic downflows exceeding 100 km/s. The persistent heating over the LB is counterintuitive as the underlying structure would radiate the majority, if not all, of its energy once having evolved to a strongly convective region inside the sunspot. The excess thermal energy over the LB is about 3.2×10^{26} erg and matches the radiative losses. It could be supplied by magnetic flux loss of the sunspot (7.5×10^{27} erg), kinetic energy from the increase in the LB width (4.0×10^{28} erg), or freefall of mass along the coronal loops (6.3×10^{26} erg). It remains an open question whether such persistent heating over a large height range in a granular LB is indeed a generic phenomenon.

- Solar atmospheric heating problem still remains an enigma to the solar community. Mechanical waves are one of the possible candidates, which can contribute to the heating of the solar atmosphere. Gravity waves in the lower solar atmosphere are generated by turbulent subsurface convection overshooting or penetrating locally into a stably stratified medium. In order to investigate the propagation characteristics of the solar atmospheric gravity waves, we construct two height cross-spectra and study phase and

coherence signals in the wavenumber-frequency dispersion diagrams and their association with background magnetic fields. We observe signatures of association between magnetic fields and much reduced coherence and phase shifts over height from the phase and coherence diagrams, both indicating suppression/scattering of gravity waves by the magnetic fields. Our results provide observational evidence to the earlier numerical simulations, which indicate that gravity waves are suppressed or scattered and reflected back into the lower solar atmosphere in the presence of magnetic fields. This illustrates that the dynamics of gravity waves in the solar atmosphere is affected in the presence of background magnetic fields.

Planetary Sciences

- Juno observations showed dust halo near Mars, contributing to Zodiacal light, the source of which is a puzzling question. Modelling of escaping dust ejecta from Phobos and Deimos provided higher mass escape ratio. It is found that larger particles ($>10\mu$m) are influenced by the gravitational pull of Mars, remaining in a ring/torus for a specific lifetime, subsequently getting continuously released from the gravitational effect of Mars. Such particles can create circumsolar dust ring in the orbit of Mars. The results show that Phobos and Deimos are the local sources of dust bands observed by Juno spacecraft.
- A new study focused on four intriguing landing sites (S, C1, C2 and D) situated on the De-Gerlache to Shackleton ridge region of the lunar south pole prioritized the landing sites, an important input towards the ISRO-JAXA Lupex mission. The sites were examined using data sets collected from Chandrayaan and Lunar Reconnaissance Orbiter missions. Analysis shows that site C1 must have received ejecta materials from both, de-Gerlache and Shackleton impact events, suggesting that exploration around craters with tens to hundreds of meters in diameter will lead to building up the local stratigraphy.
- Using GRAIL data, the late phase volcanism in the Australe North Basin (35.5°S, 96°E) of $\sim$ 1.7 Ga has been discovered on Moon. The basin is completely obliterated and could possibly be the oldest impact structure on the Moon, recently revealed.
- Mars' crust has an extensive graben system that covers a region more than 8,000 km in diameter and nearly one-third of the planet's circumference. The formation hypotheses include the formation process being either tectonic or a combination of tectonic and magmatic processes, but no consensus has been reached so far. In this study, the basaltic subsurface unit confirmed that magmatism is involved in the formation process of these graben systems.
- Nitrogen isotopic composition in ordinary chondrites is utilized to constrain the nebular gas composition. The heliocentric location of the formation of ordinary chondrite in the early solar system is accessed using their nitrogen isotopic composition. Nitrogen isotope ratios of ordinary chondrites indicate their formation at a distance of $\sim$ 2.5 AU from Sun. No correlation is observed between petrologic types and nitrogen isotope ratios of the ordinary chondrites.
- Different constituents of ordinary chondrite Itawa Bhopji, such as chondrules, metal separate as well as dark and light lithologies were examined for noble gas and nitrogen isotopic composition. The trapped noble gases suggest that the gases in this meteorite are a mixture of implanted gases and of primordial origin. Distinct nitrogen isotopic signatures in chondrule indicate their formation at a distinct location as compared to the metal separates.
- A lobate scarp, estimated to be around 20-30 million years old, is located near the proposed landing site (PLS) for ISRO's Chandrayaan-3 mission. This feature is associated with multiple craters, showing evidence of fresh and faded boulder-fall trails. The lobate scarp may have been responsible for a moonquake with an estimated maximum moment magnitude of 6.3. The seismometer onboard the Chandrayaan-3 Vikram lander could provide a valuable data to characterize these shallow moonquakes.
- The most recent meteorite 'fall' in India, as per Met. Bulletin database, was witnessed on January 24, 2023, at 06:30 IST in Kopargaon taluka of Ahmednagar district, Maharashtra. The collected mass of the meteorite fragments was about $\sim$ 1 kg. The rocky meteorite can be assigned to LL-group ordinary chondrite of petrologic type-5. The spectral resemblance of the Kopargaon LL chondrite suggests that it could be the fragmental breccia of an S-type asteroid that was probed by the Hayabusa-1 mission.
- Alpha particle-induced X-ray spectroscopy (APXS) detects characteristic X-ray lines emitted by atoms excited by incident alpha particles and X-ray radiation. A novel method for estimating the anticipated APXS signals from prominent K_α lines for various lunar compositions (KREEP basalt and FAN considered here) is presented. All the major element K_α lines are well above the back-ground for the high Al basalt composition, with the exception of the Na K_α line. Modelling results suggest that an alpha-induced X-ray spectrometer on a lunar rover can detect K_α lines of major elements and can distinguish different lunar compositions.
- A magnetically controlled ionopause boundary at Mars is reported for the first time, using the MAVEN data. It is proposed that the horizontal magnetic field can form such ionopause within the magnetic pile-up boundary during the daytime, if the time and location of the magnetic anomaly coincide with the ion and electron density measurements. The night-time ionosphere is expected to be produced within the magnetic pile-up boundary due to the transportation of plasma from dayside to nightside across the terminator by a horizontal plasma flow velocity, as has been predicted by the previous studies.

Space and Atmospheric Sciences

- A comprehensive investigation of aerosol characteristics and associated radiative effects using high-quality ground-based observations from several locations in the Indo-Gangetic Plain (IGP), the Himalayan foothills and the Tibetan Plateau, along with satellite measurements, and model simulations, for the first time, was performed. The analysis revealed that aerosol optical depth (AOD) is ¿ 0.30 at all sites confirming that this region is heavily polluted. AOD is higher over elevated locations in the Himalayas. Despite being located at a higher elevation, Kathmandu in the Himalayas, has a lower single scattering albedo (SSA) than Lumbini and Pokhara, indicating that it is likely a significant light-absorbing aerosol source to

Himalayas. This finding confirms that the fine mode particles which are easily transported are higher at higher altitudes in the central Himalaya foothills and are also more absorbing in nature giving rise to lower SSA values.

- Our analysis revealed that the aerosol radiative forcing efficiency (ARFE) in the atmosphere is significantly high over the IGP and the foothills of Himalayas (80-135 Wm^{-2} per unit aerosol optical depth (AOD)), with values being greater at higher elevations in the Himalayas. The mean ARFE over the Himalayas is 2-4 times higher in this case than polluted sites in South and East Asia because of higher AOD and aerosol absorption (lower SSA). Further, the observed annual mean aerosol heating rates (0.5-0.8 K/day), which are significantly higher than those previously reported values, implying that the aerosols alone could account for more than 50% of the total warming (aerosols + greenhouse gases) of the lower atmosphere and surface over this region.
- Non-methane hydrocarbons (NMHCs) constitute a major fraction of volatile organic compounds (VOCs), which play a vital role in atmospheric chemistry and air quality. To characterize the impact of South Asian outflow and the role of oceanic sources, we performed in-situ measurements of key NMHCs over the Arabian Sea in winter. Various sources, such as anthropogenic emissions from the Indian subcontinent, oceanic emissions, biogenic emissions from the Western Ghats, and shipping lane emissions, contributed to the observed NMHCs concentrations. However, marine sources dominated the measurements in the remote regions. Light alkenes showed a higher potential for ozone and organic aerosol formations, accounting for $\sim$70% of total formation potentials among the measured NMHCs. The simultaneous measurements of organic aerosol mass concentrations further indicated the role of light alkenes in the new particle formation over the equatorial Indian Ocean. VOCs, with their diverse sources, influence the atmospheric chemistry and radiative balance over coastal as well as remote marine environments. Interestingly, the levels of NMHCs measured in this study are much higher than those measured about two decades ago during the INDOEX campaign. Therefore, it is essential to improve our understanding of the sources and effects of VOCs to develop effective strategies for mitigating their negative impacts over Indian subcontinent and northern Indian Ocean.
- Recent studies on atmospheric clouds and boundary layer investigated the diverse atmospheric phenomena affecting the Western-Indian region. Ground-based Raman Lidar observations revealed the intricacies of regional dust storms over Western India, showcasing heavy dust loading from the Arabian Peninsula and the Middle East. Another study emphasized boundary layer clouds in the same region, illuminating their sensitivity to surface forcing and their impact on climate dynamics. Further investigations explored the complex relationship between aerosols, clouds, and rainfall variability over the Western-Indian region and the Arabian Sea, underscoring the nuanced interplay between these factors under different meteorological conditions. These findings collectively contribute to a deeper understanding of regional weather patterns and global atmospheric phenomena, informing efforts to mitigate environmental impacts and enhance climate resilience.
- Atmospheric chemistry in the Himalayan region is of immense significance in understanding the regional to global climate. Yet, there is paucity of such data over rapidly developing valleys of the Himalaya. We conducted a systematic ground-level ozone observations over the Doon valley during 2018-2023 and carried out a comprehensive analysis in conjunction with satellite data and model results. The observed ozone variability is explained mainly by the regional photochemistry whereas downward transport plays a minimal role. Noontime ozone build-up is typically strongest during April-June attributed to dry-warm meteorological conditions plus biomass-burning emissions. Ozone formation in the region is sensitive to the abundance of both organic compounds as well as nitrogen oxides. The global model successfully reproduced observed day-to-day ozone variability but overestimated the levels. A statistical model has been applied to compute ozone variability using relevant satellite observations and meteorological data as inputs. The datasets and scientific findings will be helpful in designing strategies to improve air quality over the Himalayan region.
- Chlorine (Cl) species can strongly impact the atmospheric composition and oxidation capacity. However, atmospheric models lack the detailed chemical mechanisms of chlorine. We extended the gas- and aqueous-phase Cl chemistry of the community atmospheric chemistry box model CAABA/MECCA. The updated model has been applied to urban environments of contrasting NO_x conditions: New Delhi, India and Leicester, UK. The model shows a sharp build-up of Cl at sunrise through Cl_2 photolysis in both the environments. High-NO_x conditions in Delhi tend to suppress the night-time build-up of N_2O_5 due to titration of O_3, in contrast to Leicester. The contribution of Cl to the atmospheric oxidation capacity is significant and even exceeds that of OH during the morning hours in Leicester. Sensitivity simulations suggest that the additional consumption of organic compounds by chlorine chemistry enhances OH, HO_2, and RO_2 near the sunrise. The updated model and simulation results have implications for future studies on air chemistry and urban air quality, globally.
- Stable Auroral Red (SAR) arcs are zonally elongated and latitudinally confined red line emission regions that occur over mid-latitude upper atmosphere and are formed by the interaction of cold plasmaspheric particles with hot energetic ring current ions. They form one of the direct evidence of magnetosphere-ionosphere (M-I) coupling during Space Weather events. By employing a high spectral resolution measurements PRL scientists have been able to make the first observations of the daytime SAR arcs. As the SAR arcs are caused by the enhancement of electron temperature in the ionosphere during space weather events, detailed investigations by the process of forward modelling enabled estimation of the magnitudes of electron temperatures associated with the measured daytime SAR arcs events were found to be in the range of 3500-4400 K. Such results during the daytime open up new possibilities of investigating the underlying mechanisms of magnetosphere-ionosphere coupling that are operative during space weather events in the daytime.
- Using ground-based high-resolution imaging measurements from a mid-latitude location, PRL scientists explained an anomalous enhancement (greater than 1 kilo Rayleigh) in the brightness of OI 630 nm dayglow that is attributed to a phenomenon called the storm enhanced density (SED). SED can occur, on occasions, during geomagnetic disturbances

and signifies one of the various manifestations of the space weather effects on high and mid-latitudes. Collocated Millstone Hill Incoherent Scatter Radar and large-scale variation in total electron content, as obtained from world-wide distributed GNSS receivers attest to this new finding by daytime optical emissions.

- Stream Interface Regions (SIR) in the solar wind have the potential to cause severe space weather disturbances on the Earth. In order to understand the changes in the alpha-proton ratio (A_{He}) in the SIR, events during solar cycles 23 and 24 are investigated. While past studies explored A_{He} enhancements in coronal mass ejections, attention to A_{He} in SIRs has been limited. It is shown that alpha populations are enhanced at higher bulk velocity angles, particularly in the fast wind regions of SIRs, enhancing A_{He}. The investigation brings out, for the first time, the salient changes in A_{He} in SIRs for the two solar cycles and highlight the importances of bulk velocity angle and differential velocity in the fast wind region for the changes in A_{He} in SIRs
- Suprathermal particles in the interplanetary (IP) medium act as seed population for solar energetic particles that pose severe threat to space-based technologies. The generation mechanism(s) of suprathermal populations is(are) not well-understood. By analyzing variations in suprathermal $_4$He, O, and Fe for 20 SIR events recorded by STEREO-A spacecraft during 20072014, it is found that the spectral indices of these elements vary in the range of 2.064.08, 1.854.56, and 2.114.04, respectively, for 19 events. This indicates presence of multiple generation processes. However, in one special case, all three suprathermal elements show nearly identical ($\sim$1.5) spectral indices. It is shown that the merging and/or contraction of small-scale magnetic islands near 1 au is responsible in producing nearly identical spectral indices for three different elements with different first ionization potentials and mass-to-charge ratios.
- First signature of two-step nonlinear interactions in the middle atmosphere during sudden stratospheric warming was found. The interaction involved the travelling as well as stationary planetary waves in the stratosphere to generate zonally symmetric planetary wave which propagated upward to interact with the semidiurnal tide in the mesosphere resulting in the observed sidebands around the semidiurnal period (12 h)
- Circulation patterns during two rare sudden stratospheric warming events (2002 and 2019) in the Southern Hemisphere were studied. Our novel analysis methodology revealed weak circulation features associated with the warming events. A tropical connection to the polar disturbances during the pre-warming phase was found.

Geosciences

- A study was conducted to decipher the black carbon (BC) transport pathway to a lake (Wular Lake, Kashmir Valley, India) by utilizing the nitrogen isotopic composition of BC from a sediment core spanning the last 3740 years. The observed results indicate that higher forest fire activity during drier periods led to BC (soot) generation, leading to atmospheric transportation of BC to the lake. In contrast, wetter periods were of low forest fire activity, characterized by a dominant soil black carbon transportation via runoff aligned with relatively wetter periods.
- Temporal analysis of characteristics of total suspended matter associated organic carbon and total nitrogen from three large Asian rivers (Ganges, Mekong, and Yellow) revealed a manifold decrease in suspended load and associated C and N fluxes over the decades. This decline could be largely attributed to the reduction in the overall river discharge.
- Understanding the capacity of particulate matter (PM) to induce reactive oxygen species (ROS) generation, known as PM's oxidative potential (OP), is important for human health. The negative health effect of atmospheric particles is mainly due to their oxidative potential, which in turn depends on their chemical composition. Mitigation strategies for reducing aerosol concentrations and linking aerosol oxidative potential with health effects have been shown to be a better way to identify and regulate specific sources of toxic aerosol species.
- Carbon dioxide (CO_2) and methane (CH_4) are the most important greenhouse gases that cause global warming. In a laboratory experiment, a significant release of CO_2 and CH_4 was observed from the photochemical degradation of plastics. This finding indicates that the proper accounting of greenhouse gases (CO_2, CH_4) is necessary while studying the effects of plastics on our climate and the biogeochemical cycling of carbon in terrestrial and aquatic systems.
- Despite most prerequisites available for diazotrophic activity, nitrogen fixation rates are low in the Bay of Bengal. Higher nitrogen fixation rates occurred below rather than within the oxygen minimum zone in the Bay.
- The blocking temperature of marble and calcite and dolomite cooling rates have been estimated using carbonate-clumped isotope thermometry. This has important implications for estimating the exhumation rates and understanding the mountain-building process.
- The geomorphological study of (para/peri) glacial landforms using elemental geochemistry and optical chronology in the Southern Zanskar ranges, NW Himalaya, indicates that the cirque glaciers advance during the interaction of monsoon and westerlies during cooler climate phases. The regional dryness facilitated by rising winter temperature markedly increased since 2500 years. This led to the major retreat of the glaciers as well as the degradation of permafrost conditions.
- The hypothesis proposed earlier for the discrepancies between the terrestrial cosmogenic nuclide (TCN) and the OSL ages on the stratigraphically equivalent deposits was proven and quantified by the TCN ages from the Karakoram and Ladakh Ranges. The study highlights the significance of geological processes in determining the suitable glacially eroded surfaces to restrain the age of glacial advances, while other bedrock surfaces and boulders give insight into various peri-glacial processes and landscape evolution.
- National Green Tribunal took cognizance of an article Need to declare the Higher Himalaya an eco-sensitive zone published in Current Science, 2023 and issued suo moto notice for evaluation.
- PRL scientists did an assessment of the Joshimath crisis on the request of the local people to identify the zones and probable causes of subsidence based on which report was submitted to local administration for perusal. The report was published in Current Science, 2023.

Theoretical Physics

- Using the phenomena like how Earth's path around the Sun changes slightly (perihelion precession), how light bends around massive objects (gravitational light bending), and delays in signals passing through gravitational fields (Shapiro time delay) constraints were obtained on a new type of long range force called the monopole-dipole force acting between polarized and unpolarised objects.
- Using a liquid Argon based neutrino detector it was shown how the combination of beam and atmospheric neutrinos can help in resolving the ambiguity in determining the octant of the neutrino mixing angle involved in governing the flavour change of neutrinos coming from these sources in the presence of an additional sterile neutrino.
- New deep-learning algorithms, especially graph-based (GNN) ones, demonstrate the exceptional capability to analyze enormous amounts of data produced at particle collision experiments like the Large Hadron Collider (LHC). Such study also provides a robust way to understand the strong force, a fundamental force that binds quarks together within protons and neutrons. Quantum Chromodynamics (QCD) excels in the description of strong interaction. However, IR and C (IRC) singularities arise when dealing with low-energy emissions or collinear configurations, hindering reliable predictions from calculations. IRC safety is a property that ensures a physical observable (i.e. a measurable quantity in an experiment) remains unchanged even if there are soft emissions or collinear splittings. Crucial work at PRL provides a formalism to construct such an IRC-safe graph neural network algorithm, making the network output less sensitive to low-energy effects. We find such a general but straightforward architecture to perform on par with other IRC unsafe algorithms.
- Dark matter, the invisible material dominating our universe, remains a mystery. While its existence is well-supported, its properties are unknown. This study refines the theoretical upper limit on dark matter particle mass. The critical concept is lent from the unitarity calculation of the scattering process, which ensures particle interactions don't become infinitely strong. An estimate was made to calculate the minimum number of dark matter particles needed to explain observations, which, in turn, limits how massive these particles can be for different cosmic expansion histories.
- We show how an analysis of statistical distributions, specifically electron waiting times and the correlation between them, help in understanding the properties of unconventional superconductors. We consider an interferometer formed by a superconducting loop with a controllable phase difference and placed at the geometrical edges of a quantum spin Hall effect system. The peculiar property of the edge states enables the separation of transferred electrons from the holes into two separate leads controlled by the phase difference of the loop. The scattering processes inside the junctions lead to the formation of zero-energy bound states, called Andreev bound states, at a particular phase difference. We show that waiting times for the transmitted electrons are sensitive to it. However, the waiting times for the Andreev-reflected holes remain insensitive. These two different waiting times show opposite behaviors when we consider their correlation. Some of the cross-distributions also show unique features indicating the properties of unconventional superconductors.
- Reliable and accurate predictions of jet-veto cross-sections in processes such as Higgs boson and W^+W^- production, which are commonly used to study new physics at the LHC, are indispensable. In these processes, vetoing energetic jet activity is a crucial tool for suppressing backgrounds and enabling new physics searches at the LHC. However, the introduction of a veto scale can introduce large logarithms that may need to be resummed. We present an implementation of jet-veto resummation for color-singlet processes at the level of extremely accurate (N^3LL_p+NNLO) predictions and apply on mono-boson and di-boson production processes. We describe in detail our formalism and compare with previous public codes that operate at the level of next-to-next-to-leading logarithmic (NNLL) accuracy. Our higher-order predictions improve significantly upon NNLL calculations by reducing theoretical uncertainties. We demonstrate this by comparing our predictions with the experimental results.

Atomic, Molecular and Optical Physics

- Our rigorous characterization of the mean photon number per pulse employing multiple detectors enables the detection of adversarial attacks and the estimation of secure key rates more precisely, thus strengthening the overall security of the quantum key distribution (QKD) system.
- Our results with imperfect homodyne detection performed using limited resources pave the way for the resource-efficient realization of optical homodyne tomography and continuous-variable quantum key distribution.
- Continuous variable (CV) QKD offers many advantages over discrete variable (DV) QKD since it is cost-effective, compatible with current classical communication technologies, efficient even in daylight, and gives a higher secure key rate. Keeping this in view, we demonstrate a discrete modulated CVQKD protocol in the free space which is robust against polarization drift.
- A variety of relativistic many-body methods were developed to examine the accuracy of the calculated parity-violating electric dipole $(\mathrm{E1_{PV}})$ amplitudes in $^{133}\mathrm{C}s$. In the last decade, many different groups had claimed the accuracy of these results below 0.5%, but they differed by 1% from each other. A major issue in these calculations was the opposite sign reported among the core correlation contributions. Using our newly developed methods, the underlying cause of sign discrepancies in the previously reported results was addressed and a possible scope of improvement in the calculation of $\mathrm{E1}_{pv}$ in $^{133}\mathrm{C}_s$ was suggested. This has implications to probe beyond the Standard Model of particle physics.
- Contributions to the electric dipole moment of $^{129}\mathrm{X}e$ from the parity and time-reversal violating pseudoscalar-scalar and scalar-pseudoscalar electron-nucleus interactions and electric dipole moments of electrons coupled with internal electric and magnetic fields were estimated by developing linear response relativistic coupled-cluster method. The random phase approximation was also applied to reproduce results from the previous calculations. By taking the differences in the results between both methods, the importance of Brueckner pair correlation effects was demonstrated. Combining atomic results with the nuclear shell-model calculations, constraints on the pion-nucleon coupling coefficients, and the EDMs of a proton and a neutron were imposed.

- The static and dynamic electric dipole polarizabilities $(\alpha \mathrm{F})$ of the hyperfine levels of the clock transition in $^{133}\mathrm{C}s$ were calculated precisely. The scalar, vector, and tensor components of $\alpha \mathrm{F}$ were estimated by expressing as the sum of valence, core, core-core, core-valence, and valence-core contributions that arose from the virtual and core intermediate states. The dominant valence contributions were estimated by combining a large number of matrix elements of the E1 and magnetic dipole hyperfine interaction operators from the relativistic coupled-cluster method and measurements. Very good agreement of the static values for the scalar and tensor components with their experimental results suggest that the estimated dynamic $\alpha \mathrm{F}$ values were very reliable and they can be used to estimate the Stark shifts while conducting high-precision measurements at the respective laser frequency using the clock states of $^{133}\mathrm{C}s$.
- High-accuracy calculations of isotope shift (IS) factors of the states involving the D1 and D2 lines in Zn II were performed using analytical response relativistic coupled-cluster theory. Together with a global fit to the available optical IS data, nuclear-model independent, precise differential radii for a long chain of Zn isotopes were estimated. These radii were compared with the ones inferred from muonic x-ray measurements. Some deviations were found, which were ascribed to the deformed nature of Zn nuclei that introduce nuclear-model dependency into radii extractions from muonic atoms. The study revealed that, in cases where the many-body atomic calculations of IS factors are well established, optical determinations of differential radii were more reliable than those from the muonic x-ray measurements, opening the door to obtaining more trustworthy nuclear radii across the nuclear chart.
- We have experimentally demonstrated the mathematical concept of arithmetic of infinity using structured optical beams
- We have demonstrated quantum sensing using single photons at a near-video frame rate. Typically, the use of single photons makes the high-resolution quantum sensing a slow process. However, by finding a trade-off between the spectral width of the single photons and the rate of the single photon generation by optimizing the length of the nonlinear crystal we have experimentally demonstrated high-speed quantum sensing measurements with high resolution.
- We have developed an optical mirror whose transmission and reflection can be controlled dynamically without changing the experimental setup. By exploring the PancharatnamBerry phase in a Sagnac resonator we demonstrated the mirror with transmission varying from 0-100%.
- From irradiation experiments by the PRL Team, the Discovery of ozone on Jupiter's moon Callisto and the 310 nm unknown band on Callisto by comparing the Hubble Space Telescope and laboratory analog data.
- Finding an amorphous icy mantle, 1-propanol, well beyond the melting point through experimental Astrochemistry at PRL. This is the first molecule reported to show such a behavior.
- The detection of Pentacene, a Polycyclic Aromatic Hydrocarbon (PAH) molecule, is reported on a sample of comets, which strengthens the fact that PAH molecules are widespread in the solar system and Interstellar medium (ISM). This work was carried out in collaboration with SPL, and VSSC.
- The study of the morphology and stability of 1 & 2 Cyanonaphthalene, PAH molecules conducted in PRL shows that PAH molecules can remain stable in an amorphous state even at relatively higher temperatures of 250 K than previously known. This implies that PAHs can be present in icy mantles at high temperatures and potentially participate in further chemical reactions under the low temperatures and pressure found in space.
- We improved the existing luminescence dating technique by identifying a new Post Violet Infrared Luminescence (PVIR) signal for natural mineral feldspar. This signal has better stability (zero fading) over geological timescales and a higher age limit (higher saturation dose) compared to conventional methods. We also investigated the luminescence mechanism and developed a systematic optimized laboratory protocol for using this signal.
- We have developed a new methodology for the quantification of sedimentary provenance in river basins using luminescence and successfully demonstrated sediment budgeting for the first time for using luminescence in different river systems of India.
- We have determined Holocene slip rates along the Himalayan Frontal Thrust in the western Himalayan Nahan salient. It is important to consider seismic hazards in the region. The work suggests that there is a seismic quiescence of 600700a which results in a $\sim$ 6.28.5m slip deficit on the HFT. This could trigger a Mw $\geq$ 7.7 earthquake in the region.
- A comprehensive study on expansion dynamics of nanoparticle-enhanced laser-induced breakdown spectroscopy was performed. We have demonstrated that the existing plume propagation models can be used to explain the dynamics of the laser plasma even in the presence of nano-particles. The results were validated in different ambient conditions and corresponding plume propagation models were found to have an excellent match with the experimental results.

Collaborations of PRL with National/International institutions/universities

Astronomy and Astrophysics

- **Area of Collaborations:** Evolution of Elemental Abundances in Hot Active Region Cores from Chandrayaan-2 XSM Observations, Multiwavelength Observations of a B-class Flare Using XSM, AIA, and XRT, Optical spectroscopy of comets using Hanle Echelle Spectrograph (HESP), Long-term spectroscopic monitoring of comet 46P/Wirtanen, Understanding the relative importance of magnetic field, gravity, and turbulence in star formation at the hub of the giant molecular cloud G148.24+00.41, Deciphering the Hidden Structures of HH 216 and Pillar IV in M16: Results from JWST and HST, Galactic 'Snake' IRDC G11.11-0.12: a site of multiple hub-filament systems and colliding filamentary clouds, Fragmentation and dynamics of dense gas structures in the proximity of massive protostar W42-MME, New insights in the bubble wall of NGC 3324: intertwined sub-structures and a bipolar morphology uncovered by JWST, AFGL 5180 and AFGL 6366S: sites of hub-filament systems at the opposite edges of a filamentary cloud, Star-forming site RAFGL 5085: Is a perfect candidate of hub-filament system?, The Giant Molecular Cloud G148.24+00.41: gas properties, kinematics, and cluster formation at the nexus of filamentary flows, The statistical analysis of the dynamical evolution of the open clusters, Tracing the Outer spiral arm of the Milky Way using red clump stars, Warp and flare of the old Galactic disc from the red clump stars, Exploring the short-term variability of H_{alpha} and H_{beta} emissions in a sample of M dwarfs, Formation of Carbon monoxide and Dust in the ejecta of a Recurrent Nova V745 Sco, Estimating the dust properties in galactic nova V445 Puppis, On the cyclotron absorption line and evidence of the spectral transition in SMC X-2 during 2022 giant X-ray outburst, Hard X-ray polarization measurement for Cygnus X-1 with AstroSat/CZTI, Long-term Study of the First Galactic Ultraluminous X-Ray Source Swift J0243.6+6124 Using NICER, Investigation of an X-ray flaring event in NLS1 galaxy NGC 4051, Survey of Bare Active Galactic Nuclei in the Local Universe ($z < 0.2$). On the Origin of Soft Excess, Long-term X-ray temporal and spectral study of a Seyfert galaxy Mrk 6, AGN feedback through multiple jet cycles in Seyfert galaxy NGC 2639, Multi-epoch hard X-ray view of Compton-thick AGN in Circinus Galaxy, Intra-night optical variability of peculiar narrow-line Seyfert 1 galaxies with enigmatic jet behaviour, Prospects of measuring gamma-ray burst polarization with the Daksha mission, Discordance of the cosmic radio dipoles with the cosmic microwave background dipole, A peculiar motion of Solar system not conversant with different amplitudes of various cosmic dipoles – implications for the cosmological principle, Double Scrambler Design and Implementation in PARAS-2 to achieve $sub-m$ s^{-1} RV Precision, Indigenous Development of Atmospheric Dispersion Corrector (ADC) for the PARAS-2 Spectrograph, Indigenous Development of new Mirror Coating Plant for the 2.5m Telescope, First re-coating of the PRL 2.5m telescope mirrors, Development of ProtoPol: A medium resolution echelle Spectro-polarimeter for PRL Telescope, Characterization setup for infrared photometric calibration for NISP, HAWAII-2RG detector installation in cryogenic dewar and its dark characterization.
- **Collaborating Institutes/Universities:** DAMTP, Cambridge University, UK., CFA, Harvard University, US., Indian Institute of Astrophysics, Bangalore., CalTech and the TRAPPIST group:(University of Liege, Belgium, University of Liege, Belgium under the Indo-Belgium BIPASS project., IISER, Tirupati, ASIAA, Taiwan, IAPS, Italy., ARIES, INAF, Italy, T. Baug (SNBNCBS), and Y. D. Mayya (INAOE, Mexico)., IISER Tirupati, ARIES., IAP RAS, Russia, INAOE, Mexico, CHRIST University, TIFR,PMO, CAS, China., SNBNCBS, Jodrell Bank Centre for Astrophysics, Manchester, UK, TIFR, Mumbai, IIST, Thiruvananthapuram., ARIES, Nainital, Ravishankar Shukla University, Raipur., Lagrange Laboratory, University C^{o}te d'Azur, Nice, France., Instituto de Astronomia, Universidad Catolica del Norte, Antofagasta, Chile, Leibniz-Institut for Astrophysik Potsdam (AIP), Potsdam, Germany.", University of Minnesota, USA, Keel University, UK., National Space Institute, Denmark., Stanford University, IUCAA,INAF-IAPS, Italy,Ashoka University,IIT Bombay., Institute of Astronomy, National Tsing Hua University, Taiwan., University of Manitoba, Canada, Institute of Astronomy, National Tsing Hua University, Taiwan, and S. K. Chakrabarti of Indian Centre for Space Physics, Kolkata., Instituto de Estudios Astrof'isicos, Facultad de Ingenier'ia y Ciencias, Universidad Diego Portales, Av. Ej'ercito Libertador 441, Santiago, Chile., IIT Mumbai, NCRA-TIFR, Pune., Universidad Diego Portales Santiago Chile,Inter-University Centre for Astronomy and Astrophysics (IUCAA) Pune, University of Southampton, UK., European Southern Observatory, Santiago, Chile, University of Oklahoma, USA.

Solar Physics

- **Area of Collaborations:** Global Oscillation Network Group (GONG) Program, Indo US Science and Technology Forum (IUSSTF) on "CME propagation in the interplanetary space to predict Bz and space weather impact", Indo-Uzbek INT/UZBEK/P-15, Indo-German DST-DAAD personnel exchange program, Circular ribbon flare triggered from an incomplete fan-spine Configuration, Origin of extreme solar eruptive activity from the active region NOAA 12673, On the propagation of gravity waves in the lower solar atmosphere

in different magnetic configurations, Rotation of a Stealth CME on 2012 October 5 Observed in the Inner Heliosphere, Source region of 3-min waves observed in coronal fan loops rooted in sunspot umbra, Classification of circular polarization Stokes profiles in sunspots using k-means clustering, Hall effect on the magnetic reconnections during the evolution of a three-dimensional magnetic flux rope, Magnetohydrodynamics simulation of magnetic flux rope formation in a quadrupolar magnetic field configuration, Study of Reconnection Dynamics and Plasma Relaxation in MHD Simulation of a Solar Flare, Solar Hysteresis Pattern and Spectral Components in TEC Time Series (GPS and TIE-GCM) of the Quadrilaterally Coupled Geomagnetic Conjugate Low-latitude Stations, Observations of Geomagnetic Crochet at High-Latitudes due to X1.5 class Solar Flare on 3 July 2021.

- **Collaborating Institutes/Universities:** National Solar Observatory, Boulder, CO, USA, Indo US Science and Technology Forum (IUSSTF) on, Indo-Uzbek INT/UZBEK/P-15, Leibniz Institute for Astrophysics Potsdam(AIP), Potsdam, Germany, Univ. of Graz, Austria., Indian Institute of Astrophysics, Bengaluru., University of Huntsville, Alabama, GSFC, NASA, Patna University, University of Oslo, Norway,University of Alabama, Huntsville, USA, National Astronomical Observatories, Beijing, China, Tripura University, Agartala.

Space and Atmospheric Sciences

- **Area of Collaborations:** Daytime upper atmospheric dynamics, Daytime equatorial dynamics, Equatorial dynamics in the nighttime, Ionospheric physics, Ionospheric Physics, Magnetosphere-Ionosphere Coupling, Ionospheric Physics, Geomagnetic storm, Magnetospheric Substorm, Solar Flare, Solar wind Physics, Heliospheric Physics, Solar wind, Space weather modeling, Geomagnetic storm, Continuous atmospheric measurements of C_2-C_{12} hydrocarbons at IIT Delhi Sonipat Campus, to understand the role of transport from upwind of Delhi in the winter pollution events (November-Present), Laboratory experiment to study the evolution of ambient VOCs composition at varied oxidation levels in oxidation flow reactor (OFR)., Effect of the sea and land breeze circulations in the levels and compositions of VOCs in the coastal environments, Laboratory experiments to characterize the VOC composition in biomass burning plumes using open combustion set-up, Air quality assessment techniques, Air pollution from informal electronic waste recycling and allied sectors in India, Investigate relationship between PM (particulate matter) and ozone over different urban environment in India, CarbOnaceous AerosoL Emissions, Source apportionment & ClimatE impacts (NCAP-COALESCE), Effect of lockdown on pollutant levels in the Delhi Megacity: Role of local emission sources and chemical lifetime, Balloon borne observations of tropopause aerosol layer, SSW influences in the MLT region, Trace gas measurements, photochemical box modelling, chemistry-climate modelling, machine learning of atmospheric variability, atmospheric dynamics over Himalaya, Middle atmospheric wave dynamics, Mesospheric wave activities, MLT region wave dynamics, MLT coupling phenomena, MLT wave coupling using Airglow observations.

- **Collaborating Institutes/Universities:** Jawaharlal Nehru Technological University, Hyderabad, Indian Institute of Geomagnetism, Navi Mumbai, Space Physics Laboratory, Vikram Sarabhai Space Centre, Trivandrum, Utah State University, USA, Indian Institute of Geomagnetism, Navi Mumbai, Los Alamos National Laboratory, Space Science and Applications Group, Los Alamos, NM, USA, IIT-Roorkee, ISAS, Department of Physics and Engineering Physics, University of Saskatchewan, Saskatoon, SK, Canada, NASA Goddard Space Flight Center, Greenbelt, MD, 20771, USA, The Catholic University of America, Washington, DC 20064, USA, IIT- Indore, GFZ German Research Centre for Geosciences, Potsdam, Germany, National Atmospheric Research Laboratory, Gadanki, Meteorological Research Institute (MRI), JMA, Tsukuba, Japan, IIT Delhi, CSIR-NIO, Goa, Indian Institute of Technology, Bombay, Mumbai, SRM Institute of Science and Technology, Chennai, Central University of Rajasthan, Ajmer, Multi Institute National Project with IIT Bombay as lead institute, Department of Atmospheric Science, Central University of Rajasthan, Ajmer, Multi institute field campaign with NASA Langley Research Center, Hampton, VA, USA as lead institute, Institute for Space-Earth Environmental Research (ISEE), Nagoya University, Japan, Space Applications Centre, Ahmedabad; SPL VSSC, Thiruvananthapuram; ARIES, Nainital; Dibrugarh University, Dibrugarh; IIT Madras, Chennai; ECMWF, UK; Max Planck Institute for Chemistry, Germany, National Institute for Space Research, So Paulo, Brazil, British Antarctic Survey, Cambridge, UK, Leibniz Institute for Atmospheric Physics (IAP), Germany, National Physical Laboratory, New Delhi, Aryabhatta Research Institute of Observational Sciences, Nainital.

Planetary Sciences

- **Area of Collaborations:** Martian Geology, Lunar Geoscience, Planetary mission data science, Analysis by lab instrumentation related to planetary samples, Meteorites under shock metamorphism, Iron meteorite, Stony irons and alloy, Experimental Simulation of Lightning and Development of Lightning Detection Antenna for Future Planetary Missions, Spectropolarimetric imaging of lunar surface features, CLASS-M3 based elemental estimation of Moon at global scale, "Plasma Physics (Project: Acoustic Solitary/ Shock Waves in Multicomponent Quantum Magneto Plasma: Application in Communication Technology)," Plasma environment on Moon (Project: Effect of protons in the near lunar wake on the nightside surface charging), "large Modelling of Planetary Atmosphere, Simulations and Interstellar Medium, Turbulence dynamics in the inner solar corona from radio sounding experiments using the Akatsuki spacecraft," Moon: Plasma Sheath around Chandrayaan-3 Landing Site: A Case Study, Magnetically controlled ionopause boundary at Mars, Phobos and Deimos as Source of Dust Observed by Juno Spacecraft, The magnetically controlled ionopause boundary of Mars, Chemistry of hydrated, nitrogenated and deuterated cluster ions: NOMAD observations, Using a Quench Level Approximation to Estimate the Effect of Metallicity on the Abundances of N-bearing Species in H_2-dominated Atmospheres, Formation of sodium-bearing species in the interstellar medium, "large Remote Sensing

and Data Analysis, Potential landing sites characterization on lunar south pole: De-Gerlache to Shackleton ridge region," Contextual Characterization Study of Chandrayaan-3 Primary Landing Site, Discovery of Late phase volcanism in Australe North, possibly the oldest Impact Basin on the Moon, Geologic investigation of the lobate scarps in the vicinity of Chandrayaan-3 landing site in the southern high latitudes of the moon, Subsurface study of the Tharsis graben system using SHARAD data, Evolutionary history of western Eos Chaos of Valles Marineris, Mars: Insights from morphological characteristics, "large Meteorite, Analogue and Laboratory Studies, The Diyodar meteorite fall in India," Meteorite fall in Bhojade village, Kopargaon taluk, Ahmednagar district, Maharashtra, India, Nitrogen isotopic signature in the ordinary chondrites, Noble gas and nitrogen investigation in two ordinary chondrites Zag and ALH 77216, Chondrules, metal separates and different lithologies of Indian chondrite Itawa Bhopji, Tsunami or Storm? Mega-wave deposits on the southern tip of Eyre Peninsula, Whalers Way, South Australia, Comparative Analysis of Calcium-Aluminum Inclusions in Mukundpura CM2 and Murchison CM2 Chondrites, "large Developmental Work, Supra Thermal & Energetic Particle Spectrometer (STEPS) - onboard Aditya-L1 mission," Neutral & Ion Mass Spectrometer for the study of planetary atmospheres, Characterization of the NaI (Tl) and $CeBr_3$ Scintillation detectors with Silicon photomultiplier (SiPM) readout, Dust EXperiment (DEX) on-board PSLV C-58 (XPoSAT mission), VODEX Development, Different Design Configurations for LIVE, Planetary Environment Simulation Chamber for Experimental Simulation of Venusian Lightning, Development of a Package to Process Raw RO Data from Akatsuki, ChaSTE Experiment onboard Chandrayaan-3 Vikram Lander successfully accomplishes the first-ever thermal measurements at a high latitude location on the Moon, Development and design of quick look display and data processing algorithm for ChaSTE payload Flight data analysis, Characterisation experiments for ChaSTE under simulated lunar environment, Alpha Particle X-ray Spectrometer on Chandrayaan-3 Pragyan Rover, Inflight performance and measurements, Development of Backend Electronics for PRATHIMA payload for LuPEX mission, Development of Metrology suite and wireless sensor networks project for future missions.

- **Collaborating Institutes/Universities:** Louisiana State University, USA, Scripps Institution of Oceanography, USA, National Institute of Polar Research, Japan, U R Rao Satellite Centre, ISRO, National Geophysical Research Institute (NGRI), Hyderabad, Department of Geology and Geophysics, IIT, Kharagpur, Department of metallurgical Engineering, Technical University Dortmund, Germany, Dept. of Applied Sciences, Guwahati University, Guwahati-781014, Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvananthapuram 695024, Space Physics Laboratory, VSSC, Trivandrum; University of Tokyo, Chiba, Japan; ISTARC/ISRO, Bengaluru., Onshore Construction Company, Mumbai; Dr. P. Gläser, U R Rao Satellite centre, Bangalore, SAC Ahmedabad., Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency, Sagamihara, Japan., Planetary Science Institute, Lakewood, CO, USA, Gujarat University, Ahmedabad, Government College Kasaragod; IIST, Trivandrum; Kerala University, Trivandrum., University of Wollongong, New South Wales, Australia., IPR, Bhat., CHARUSAT, Changa.

Geosciences

- **Area of Collaborations:** Paleoclimate reconstruction, Study of paleoclimate and hydrological cycle, Isotope Hydrology, Marine biogeochemistry, Paleoclimate Studies, Environmental Biogeochemistry, Atmospheric Chemistry, To study nitrogenous aerosols over Northeast Himalaya, Exploring the Asian pollution signature in the upper troposphere/lower stratosphere region using medium duration balloon flights, Experimental study of chemical weathering of basalt., Geochemistry of Iron nodules in the sediments of the Siwalik paleosols and Ganga alluvial plains, Geochemical study of Tertiary Sediments from Tripura Area., Geochemical weathering of Rajmahal basalt., Landform evolution and Natural hazards in the Garhwal Himalaya, Biogeochemistry and climate, Basin-scale N_2 fixation, Groundwater dynamics, Paleoocean redox, Peri-glacial Geomorphology, Pb-Pb age of the Gotan Limestone, Marwar Supergroup: Implications for Ediacaran-Cambrian transition events in Peninsular India, ^{10}Be Exposure Age Dating of Moraine Boulders and Glacially Polished Bedrock Surfaces in Karakoram and Ladakh Ranges, NW Himalaya: Implications in Quaternary Glaciation Studies, Applicability of meteoric ^{10}Be in dating marine sediment cores, Multi-decadal summer monsoon rainfall trend reversals in South Peninsular India, Seasonality in groundwater recharge in Coastal Southwestern India and its hydrological implications based on stable isotopes (δ^{18}O, δD), Transport pathways of black carbon to a high mountain Himalayan lake during the late Holocene, Soil organic carbon stock and isotopic signature in tropical island mangrove forests of India, Mid-Late Holocene palaeoclimate of Kashmir Valley, Nitrogen uptake rates in the eutrophic Cochin estuary and adjacent coastal Arabian Sea, Sources, supply, and seasonality of total suspended and organic matter in large Asian rivers, Carbon and nitrogen biogeochemistry of a sub-tropical hypersaline lake, Oxidative Potential of Atmospheric Aerosols over Different Regions of India and Surrounding Oceans, Wintertime oxidative potential of PM2.5 over a big urban city in the central Indo-Gangetic Plain, Summertime oxidative potential of atmospheric PM2.5 over New Delhi: Effect of aerosol aging, Dual carbon isotope-based brown carbon aerosol characteristics at a high-altitude site in the northeastern Himalayas: Role of biomass burning, High Release of Isotopically Depleted CO_2 and CH_4 from the Photo-Degradation of Plastic: A Laboratory Study, The Bay of Bengal: An Enigmatic Diazotrophic Niche, Carbonate clumped isotopes and blocking temperatures of marbles from the Backbone Range, Taiwan, Mid-Holocene climate-glacier relationship inferred from landforms and relict lake sequence, Southern Zanskar ranges, NW Himalaya.
- **Collaborating Institutes/Universities:** Hyderabad University, IITM Pune, IIT Gandhinagar, University of Kashmir, Srinagar, Centre for Marine Living Resources and Ecology, Cochin, National Institute of Oceanography, Goa., PDEU Gandhinagar, University of Hyderabad, Ewha Womans University, South Korea, NE-SAC, Shillong, Punjabi University, Delhi University, CNRS, France, IIT Bombay, JNU, New Delhi, Pachhunga University College, Aizal, IISER Kolkata, HNBGU, Srinagar Garhwal, CSIR-NIO, Goa; PDEU, Gandhinagar; IIT Kharagpur; Manipal Institute of Technology, Manipal,

Mediterranean Institute of Oceanography (MIO), Marseille, France, Gujarat Groundwater Board, IIT Roorkee, IISER Pune, Central University of Gharwal.

Atomic, Molecular and Optical Physics

- **Area of Collaboration:** Analysis of liquid samples using LIBS and Pulsed laser ablation in liquids, Vacuum Ultraviolet (VUV) photoabsorption and photoirradiation of astrochemical ices, Hypervelocity impact experiments, Ion irradiation of astrochemical ices, Molecular dynamics simulation of astrochemical ices, High and Hypervelocity impact of astromaterials, 3D printing of lunar and martian soil analogues, Hard and soft X-ray irradiation of astromaterial and its analogues, Astrobiology - Tardigrades in extreme environments, Simulating martian conditions, Theoretical and experimental astrochemistry, Mitigating the Source-side Channel Vulnerability by Characterization of Photon Statistics, Experimental Shot Noise Measurement Using the Imperfect DetectionA Special Case for Pulsed Laser, Free space continuous variable Quantum Key Distribution with discrete phases, Scalable QKD Postprocessing System With Reconfigurable Hardware Accelerator, Forbidden transitions in highly charged ions with $(n = 4,5)d^6$ and $(n = 4,5)d^8$ configurations for making optical clocks, All-optical differential radii in Zn isotopes, High-precision electric dipole polarizabilities of the clock states in ^{133}Cs, Revisiting theoretical analysis of electric dipole moment of ^{129}Xe, Bayesian phase difference estimation algorithm for direct calculation of fine structure splitting: accelerated simulation of relativistic and quantum many-body effects, Investigating properties of heavy and superheavy atomic systems with p^3 configurations, Deciphering Core, Valence and Double-Core-Polarization Contributions to Parity Violating Amplitudes in ^{133}Cs using Different Methods, Zr^{3+} ion as a prospective THz atomic clock, Simultaneous magic trapping conditions for three additional clock transitions in Yb to search for a variation of the fine-structure constant, Simple experimental realization of optical Hilbert Hotel using scalar and vector fractional vortex beams, Near-video frame rate quantum sensing using Hong-Ou-Mandel interferometry, Dynamically tunable broadband output coupling of optical oscillators based on non-cyclic geometric phase mirror, Ultraviolet spectrum reveals the presence of ozone on Jupiters moon Callisto, Amorphous 1-propanol interstellar ice beyond its melting point, Stability and morphology of cyano naphthalene icy mantles on ISM cold dust analogs, Detection of polycyclic aromatic hydrocarbon on a sample of comets, Molecular growth of PANH via intermolecular Coulombic decay, A new post-violet infrared stimulated luminescence (pVIRSL) dating protocol for potassium feldspar, Luminescence for Sediment Budgeting, Tectonic studies along the Himalayan Frontal Thrust and implications for seismic hazard, Dating the Youngest Toba Tuff deposits in the Gundlakamma River basin and its implication for understanding Human evolution, Dating Palaeolithic tools of MIS 3 Levallois technology from Motravulapadu, Andhra Pradesh, Thermoluminescence (TL) studies of Eu^{3+} doped Sr_2YVO_6 double perovskite phosphor., Structural and optical properties of Z$n_{2.95}$G$a_2 - x$SnO$_8$: xCr^{3+}: An excellent X-ray charging-based persistent phosphor, East Antarctica ice sheet in Schirmacher Oasis, Central Dronning Maud Land, during the past 158 ka, Influence of pressure and pulse energy on the expansion dynamics of nanoparticle-enhanced laser-produced plasma, Impact of viscosity of liquid on nanoparticles synthesized by laser ablation in liquid, Analysing the Grain size and asymmetry of the particle distribution using auto-correlation technique, Vulnerability in Free Space QKD Due to Detection Coupling Mismatch, 3D incoherent imaging using an ensemble of sparse self-rotating beams, Intensity correlations in perturbed optical vortices, Endless fun in high dimensions - A quantum card game, Multi-User Nonlinear Optical Cryptosystem Based on Polar Decomposition and Fractional Vortex Speckle Patterns, Discovery of an Extremely Dense and Compact Object Embedded in the Prestellar Core G208.68-19.92-N2.
- **Collaborating Institutes/Universities:** Collaborating Institutes: PDEU, Gandhinagar & IIT, Gandhinagar, National Synchrotron Radiation Research Center, Hsinchu Science City, Taiwan & ISA, Center for Storage Ring Facilities, Aarhus, Denmark, University of Kent, United Kingdom, Tata Institute of Fundamental Research, Mumbai., Indian Institute of Science, Bangalore & Terminal Ballistics Research Laboratory, Chandigarh & University of Kent, UK, Government Arts College, Salem RRCAT, Indore, Government Arts College, Ooty, Vellore Institute of Technology, Vellore, Institute of Astronomy Space and Earth Science, Kolkata, Society for Electronic Transactions and Security, Chennai, Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China, Department of Physics, Technion-Israel Institute of Technology, Haifa 3200003, Israel., Kobayashi-Maskawa Institute for the Origin of Particles and the Universe, Nagoya University, Nagoya 464-8602, Japan and Kota Yanase of Nishina Center for Accelerator-Based Science, RIKEN, Wako 351-0198, Japan," Graduate School of Science and Technology, Keio University, 7-1 Shinkawasaki, Saiwaiku, Kawasaki, Kanagawa 212-0032, Japan, Quantum Engineering, Research and Education (CQuERE), TCG Centres for Research and Education in Science and Technology (TCG CREST), Sector V, Salt Lake, Kolkata 700091, Satoshi Ohshima of Research Institute for Information Technology, Kyushu University, 744 Motooka, Nishi-ku, Fukuoka 819-0395, Japan, Information Technology Center, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi 464-8601, Japan, Department of Chemistry, Faculty of Science, Rikkyo University 3-34-1 Nishi-ikebukuro, Toshima-ku, Tokyo 1718501, Japan., State Key Laboratory of Metastable Materials Science and Technology and Key Laboratory for Microstructural Material Physics of Hebei Province, School of Science, Yanshan University, Qinhuangdao 066004, China, Y. M. Yu of Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China, and B. B. Suo of Institute of Modern Physics, Northwest University, Xian, Shanxi 710069, China.," Department of Physics, Guru Nanak Dev University, Amritsar, Punjab 143005, Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China and Institute of Quantum Electronics, School of Electronics, Peking University, Beijing 100871, China, Shanghai EBIT Laboratory, Key Laboratory of Nuclear Physics and Ion-Beam Application (MOE), Institute of Modern Physics, Fudan University, Shanghai 200433, Chin, Beijing National Laboratory

for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China, Key Laboratory of Atomic and Molecular Physics and Functional Materials of Gansu Province, College of Physics and Electronic Engineering, Northwest Normal University, Lanzhou 730070, China., University of North Carolina Charlotte, USA., Cornel University, USA, University of Glasgow, UK., TIFR, Hyderabad, ICFO, Barcelona, Spain., Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Taiwan, Institute for Nuclear Research (Atomki), Hungary, Institute of Astronomy Space and Earth Science, Kolkata, International Space University, France, University of Kent, U.K., CSIRCentral Research Drug Institute, Lucknow, National Synchrotron Radiation Research Center, Taiwan, RRCAT, Indore, University of Kent, U.K., National Chao Tung University,Taiwan, University of Kent, U.K., Space Physics Laboratory, Vikram Sarabhai Space Center, University of Kent, U.K., International Space University, France., IIT Madras, Christ College, Kerala, Czech Academy of Sciences; IIT Gandhinagar, University of London; University of Oxford; Savitribhai Phule University, Pune; Pt. Ravishankar Shukla University, Raipur, MSU, Baroda; Eberhard-Karls-Universitt Tbingen, Tbingen, Germany, IITBHU, Varanasi; Banasthali Vidyapith ; BARC Mumbai, GSI, IIT, Gandhinagar, SRM University AP, Amaravati, Mangalagiri 522502, Andhra Pradesh, Department of Physics, National Institute of Technology, Tiruchirappalli 620015, Tamil Nadu, School of Physics, Engineering, and Technology and the York Centre for Quantum Technologies, Institute for Safe Autonomy, the University of York, YO10 5FT York, U.K, Institute of Physics, University of Tartu, W. Ostwaldi 1, 50411 Tartu, Estonia; Department of Physics, SRM University-Andhra Pradesh; School of Electrical and Computer Engineering, University of the Negev, Israel; University of Technology, Hawthorn, Melbourne, Australia, Department of Physics, National Institute of Technology, Tiruchirappalli, Photonics Laboratory, Physics Unit, Tampere University, Tampere FI-33720, Finland, Department of Physics, ,Department of Chemical Engineering, University of the Negev, P.O. Box 653, Beer Sheva 8410501, Israel; Optics and Photonics Center, Indian Institute of Technology Delhi, New Delhi 110016, The Astrophysical Journal,961,123, (2024).

Theoretical Physics

- **Area of Collaborations:** DUNE, Neutrino Physics, Unitarity bound on dark matter in low-temperature reheating scenarios, Next frontier of IRC-safe feature extraction with Graph Neural Network, Exploring a hidden window of dark matter unlocked by non-standard cosmology, BSM searches, Implications of the DLMA Solution of θ_{12} for IceCube Data Using Different Astrophysical Sources, Matter effect in presence of a sterile neutrino and resolution of the octant degeneracy using a liquid argon detector, Probing mass orderings in presence of a very light sterile neutrino in a liquid argon detector, Rho meson contribution to Neutrinoless Double Beta Decay, Axion Like Particles and heavy hadron chiral perturbation theory, Minimal spontaneous CP-violating GUT and predictions for leptonic CP phases, Gauged $\mathrm{SU}(3)_{\mathrm{F}}$ and loop induced quark and lepton masses, Quantum corrections and the minimal Yukawa sector of SU(5), Soft supersymmetry breaking as the sole origin of neutrino masses and lepton number violation, Phase-dependent charge and heat current in thermally biased short Josephson junctions formed at helical edge states, Nonlocality of Majorana bound states revealed by electron waiting times in a topological Andreev interferometer, Jet-veto resummation, Identification of 3^{rd}-generation scalar leptoquarks, Two-species k-body embedded Gaussian unitary ensembles: q-normal form of the eigenvalue density, Large-scale shell model study of two-neutrino double beta decay of ^{82}Se, ^{94}Zr, ^{108}Cd, ^{124}Sn, ^{128}Te, ^{130}Te, ^{136}Xe, and ^{150}Nd.
- **Collaborating Institutes/Universities:** Fermilab, US, Northwestern University, USA, Texas A & M USA, Oklahoma State University , USA, New York University, Abu Dhabi, United Arab Emirates, IPPP, Durham University, United Kingdom and University of Glasgow, United Kingdom, Birla Institute of Technology and Science (BITS-Pilani), Goa, ICARUS Experiment, Fermilab, US, protoDUNE Experiment, CERN, Excellence for Advanced Materials and Sensing Devices, Ruder Bokovi Institute, Zagreb, Croatia , University of Zagreb, Croatia, New York U., Abu Dhabi, United Arab Emirates, Institute for Particle Physics Phenomenology, Durham University, United Kingdom, Uppsala University, Sweden and Pablo Burset of Autonomous University of Madrid, Spain., Fermilab, USA and R. Keith Ellis of IPPP, Durham University, UK , Brookhaven National Laboratory, USA., Instituto de Ciencias Físicas, UNAM, Cuernavaca, Mexico.," IIT Roorkee, Roorkee and R. Sahu of National Institute of Science and Technology, Berhampur.

Externally Funded Projects in PRL

Externally Funded Projects in PRL

Sr. No.	Funding agency	PI	Status	Duration	Broad Area
1.	SERB-DST	Kinsuk Acharyya	Active	2023-2026	Cometary Atmosphere
2.	DST	K K Marhas	Active	2023-2026	Organics in Meteorites
3.	SERB-DST	K K Marhas	Active	2021-2024	Nascent Sun
4.	SERB-DST	R D Deshpande	Active	2023-2025	Hydrogeomorpholofy of dryland river health
5.	National Agricultural Science Fund	Sanjeev Kumar	Active	2022-2026	Biogeochemistry
6.	Directorate of Archaelogy & Museums, Gov. of Guj.	A K Sudheer	Active	2023-2026	Isotope and Chronological studies
7.	SERB-DST	Namit Mahajan	Active	2024-2027	Evaluation of Hadronic Matric Elements
8.	Indo Uzbek SWC	Nandita Srivastava	Active	2021-2024	Space Weather
9.	Indo-U.S. Science and Technology Forum	Nandita Srivastava	Active	2021-2024	Space Weather
10.	DST-CEFIPRA	Kuljeet Kaur Marhas	Active	2021-2024	Study of Chondrites
11.	DST-CEFIPRA	Neeraj Rastogi	Active	2021-2023	Exploring the Asian pollution signature
12.	DST	Arvind Singh	Active	2022-2026	Biogeochemical Cycling
13.	DST-CEFIPRA	Arvind Singh	Active	2020-2023	Dinitrogen Fixation in the Indian Ocean
14.	MoES	Arvind Singh	Active	2022-2025	Biogeochemical Processes in Marine Carbon
15.	CARS-DRDO	Goutam K Samanta	Active	2021-2023	Photonics
16.	SERB-DST (MATRICS)	Ketan Patel	Active	2022-2025	Baryogenesis in Grand Unified Theories
17.	INSPIRE-DST	Ketan Patel	Active	2015-2021	Standard Model Flavour Puzzle in Higher Dimension

Sr. No.	Funding agency	PI	Status	Duration	Broad Area
18.	DST	Varun Sheel	Active	2023-2025	Study of the Venusian climate
19.	SERB-CRG	Varun Sheel	Active	2023-2026	Study of Climate of Mars
20.	SERB-DST	Srubabati Goswami	Active	2020-2025	Probing BSM physics through neutrinos
21.	SERB-DST	Ketan Patel	Active	2022-2025	Quantifying Baryogenesis in Grand Unified Theories
22.	SERB-DST	Paramita Dutta	Active	2023-2025	Signatures of emergent phases of matter in transport phenomena
23.	SERB-DST	Satyajit Seth	Active	2023-2026	Precision calculation via non-local slicing
24.	MoES	Arvind Singh	Active	2022-2025	Role of Biogeochemical processes in controlling marine Carbon
25.	MoES	Sanjeev Kumar	Active	2021-2026	Unravelling the food-web dynamics and energy flow in the northern Indian Ocean
26.	SERB-SRG	K. Venkatesh	Active	2023-20265	Characterization of bottom side ionosphere for improving accuracies of electron content estimation

Travel Grant received by PRL members

Sr. No.	Funding agency	PI	Status	Duration	Broad Area
1.	Europlanet 2024	Kuljeet Kaur Marhas	Active	2021-2022	Study of Chondrites
2.	Europlanet grant	B. Sivaraman	Active	2021-2022	Astrochemistry
3.	The Royal Soc. Int. Exchange Grant with Uni. of Kent, UK	B. Sivaraman	Active	2020-2022	Astro chemical ices
4.	Europlanet grant to visit DLR, Berlin (Germany)	B. Sivaraman	Active	2022	Spectroscopy of shock processed planetary analogues
5.	DAAD-Research Internships in Science and Engineering Worldwide (Germany)	B. Sivaraman	Active	2022	Research Internships in Science and Engineering

Sr. No.	Funding agency	PI	Status	Duration	Broad Area
6.	Europlanet Transnational access grants [Fast track]	Surendra Vikram Singh	Active	2022	Identifying the biosignatures on icy moons
7.	Indo-German DST-DAAD personnel exchange program	Bhuwan Joshi	Active	2023-2025	Exploration of solar flare X-ray emission

Field work/ Campaigns/ Observations Conducted

Planetary Sciences

1. **Objective:** Scientific Field trip and Workshop for Martian Analogue study at Sri Lanka
   Duration: From 23/06/2023 To 10/07/2023
   Type of fieldwork: Geological mapping, in-situ analyses, Martian analogue study, sample collection etc.
   Outcome: The basic theme of the field expedition was to advance the current consensus on the role of serpentinization in the evolution of the martian crust and soils. Extensive field-work at the various locations and sampling in this purpose have been done.
   Implications Significance: The participation has helped to gain expertise in the advanced stages of research in this field. Further study of the samples along with comparison with other serpentine deposit is aligned to the context of Mars and setting up future goal of similar analog study including field work of the serpentine deposits in India.
   PRL Members Participated in Fieldwork: Amit Basu Sarbadhikari and his students.
2. **Objective:** Study of terrestrial BIF to understand the hematite formation on Mar
   Duration: From 10/10/2023 To 12/10/2023
   Type of fieldwork: Geological Sample collection (drilled core and mine site)
   Outcome: Currently petrography and sample processing for organics and isotope study.
   Implications Significance: To look for bio signatures and metabolic pathway in ancient Earths sample with a relevance to Mars.
   PRL Members Participated in Fieldwork: Dwijesh Ray and Anil D Shukla
3. **Objective:** Planetary Analogue Astrobiology Site Exploration
   Duration: From 25/07/2023 To 31/07/2023
   Type of fieldwork: To explore the Mars analogue site within the western part of the India. The Kutch region is hosting several similar landscape comparable to Mars.
   Outcome: The work carried out is submitted in national conference like MetMeSS 2023, NSSS 2024
   Implications Significance: This field work brings out the potential astrobiological site that is located in the Kutch region.
   PRL Members Participated in Fieldwork: Vijayan S, Anil Chavan, Kimi KB, Ragav K and Wafikul K
4. **Objective:** Granitic sample collection
   Duration: From 17/01/2024 To 18/01/2024
   Type of fieldwork: Geological Sample collection
   Outcome: Field study completed, sample preparation is on progress for analytical study
   Implications Significance: Understanding the crustal evolution through granitization
   PRL Members Participated in Fieldwork: Riya Dutta and Dipak Kumar Panda

Space and Atmospheric Sciences

5. **Objective:** Characterization of VOCs composition in biomass burning plumes using open combustion set-up
   Duration: December 2023
   Type of fieldwork: Laboratory experiment; Instrument handling and operations; Data analysis
   Outcome: In this collaborative study, we expect to retrieve the chemical composition and quantitative estimates of VOCs released from burning of biomass, and understand their chemical transformation mechanisms in atmosphere.
   Implications Significance: Improvement in regional chemistry climate modelling
   PRL Members Participated in Fieldwork: Ms. Mansi Gupta
6. **Objective:** Study the evolution of ambient VOCs composition at varied oxidation levels in oxidation flow reactor
   Duration: December 2023
   Type of fieldwork: Laboratory experiment with multi-instrument set-up; Instrument handling and operations; Data analysis
   Outcome: Our previous experiment showed that the levels of primary VOCs such as benzene, toluene, xylene, trimethylbenzene, etc. decreased, while OVOCs like formic acid, formaldehyde, acetone, ethanol, etc. increased substantially upon oxidation in OFR. The outcomes of this study would reveal the species important in new particles and SOA mass formation in highly polluted winters in New Delhi
   Implications Significance: Impact of transformation of reactive trace gases: Atmospheric chemistry and Air quality studies in urban regions of India
   PRL Members Participated in Fieldwork: Ms. Mansi Gupta
7. **Objective:** Investigate the role of transport from upwind of Delhi in the winter pollution events
   Duration: November 2023- March 2024 (Ongoing)
   Type of fieldwork: Station-based continuous ambient air observations
   Outcome: Wind speed and direction significantly influenced the chemical composition of VOCs and other pollutants. This Delhi upwind site (Sonipat) was also found to be dominated by traffic emissions
   Implications Significance: The outcome of these study would bring out the importance of air masses transported from biomass burning source regions, compared to local sources, as a source to haze in Delhi region
   PRL Members Participated in Fieldwork: Ms. Mansi Gupta
8. **Objective:** To install and maintenance of optical instruments NIRIS, SIRI, CMAP and MISE for multi wavelength dayglow and nightglow measurements
   Duration: 20-21 Feb 2024, 19-21 June 2023, 15-19 May 2023

Type of fieldwork: Maintenance of the optical instruments and the porta cabin
Outcome: Multi-wavelength and multi-instrument observations of the dayglow and nigh glow emission
Implications Significance: These data sets will be important to understand night time MLT dynamics and daytime thermospheric dynamics
PRL Members Participated in Fieldwork: Mr. Pradip Suryawanshi

9. **Objective:** To develop a portacabin under MOU between PRL and SUK
Duration: 18-19 November 2023
Type of fieldwork: Monitoring of the portacabin development
Outcome: Based on our requirements provision have been made for the commissioning of the optical instruments
Implications Significance: Enable commissioning of the optical instruments for airglow measurements
PRL Members Participated in Fieldwork: Mr. Pradip Suryawanshi

Geosciences

10. **Objective:** To understand the vapor dynamic at Higher altitude like Gurushikhar
Duration: Mar 2023- Nov 2023
Type of fieldwork: Rain, Surface water and vapour Sample collection
Outcome: Sample analysis is ongoing
Implications Significance: This study would help us understand the vapors dynamic at higher altitude during rainy and non-rainy days
PRL Members Participated in Fieldwork: Virendra Padhya, Akash Ganguly

11. **Objective:** Paleo biogeochemical Study of Precambrian
Duration: Mar 13- Mar 16 2024
Type of fieldwork: Rock sample collection
Outcome: Sample analysis is ongoing
Implications Significance: This study would help us understand the cycling of bioavailable element like nitrogen during the early Earth
PRL Members Participated in Fieldwork: P. Janaarthanan and Sanjeev Kumar

12. **Objective:** Biogeochemistry of Arctic region
Duration: 28 Feb-27 March 2024
Type of fieldwork: Water sample collection and experiments
Outcome: Sample analysis is ongoing
Implications Significance: This study would help us understand the cycling of bioavailable elements like nitrogen in the Arctic region. It will also help us constrain the trace gas dynamics in the region
PRL Members Participated in Fieldwork: Siddhartha Sarkar

13. **Objective:** To study soil carbon dynamics of arid Himalayan deglaciated landscape
Duration: 08-31 September 2023
Type of fieldwork: Collection of soil, water and gas samples
Outcome: Sample analysis of few parameter remains
Implications Significance: The study is warranted to improve our understanding on stability and degradation of Himalayan deglaciated soils to constrains the regional carbon budget in the warming climate. This was done by estimating organic carbon storage potential and greenhouse gas fluxes from permafrost soil of Ladakh region.
PRL Members Participated in Fieldwork: Sarwar Nizam, Mohammad Atif Khan

14. **Objective:** To investigate soil carbon storage and greenhouse gas fluxes in soils of Gujarat undergoing anthropogenic disturbances
Duration: 30 October-02 September 2023
Type of fieldwork: Collection of soil and gas samples
Outcome: Sample analysis of few parameter remains
Implications Significance: The research will enhance our understanding of changes in soil carbon storage and greenhouse gas emissions from soils undergoing anthropogenic and climatic disturbances in the form of increased salinity, Prosopis juliflora invasion, cattle grazing, forest fire, land conversion to agriculture, and grass harvesting.
PRL Members Participated in Fieldwork: Mohammad Atif Khan

15. **Objective:** Biogeochemical assessment of the Mahi River Basin focusing on the assimilation and fixation rates of carbon and nitrogen.
Duration: From 07-11 October 2023
Type of fieldwork: Sample collection of river water.
Outcome: Sample analysis is ongoing
Implications Significance: Implications Significance: The study will help us to understanding the processes like primary productivity, dinitrogen fixation and nutrients assimilation by phytoplankton in the subtropical riverine ecosystems of India.
PRL Members Participated in Fieldwork: Ajayeta Rathi, Siddhartha Sarkar, and Janaarthanan P A

16. **Objective:** To understand the crustal growth processes during the Mesoarchean. To establish the gabbro-anorthosites as lunar analogues and use them to understand the processes that aided in the formation of the lunar anorthosites, in turn exploring the genesis of the Moon. The fieldwork was part of the Ph.D. work of DST-Inspire JRF Ms. Mudita Tater.
Duration: 13 - 22 December 2023
Type of fieldwork: Geological Field work, samples were collected along the traverses
Outcome: We will have a better understanding of the crustal growth processes during the Mesoarchean. A lunar analogue will be established with gabbro-anorthosites to use them to understand the processes that aided in the formation of the lunar anorthosites, in turn exploring the genesis of the Moon.
Implications Significance: The outcrops of gabbro anorthosites occurring in this part of the Singhbhum Craton vary significantly with respect to their field associations and mesoscopic features. Examining this variation and tracing them to geochemical variations will aid in the understanding of crustal growth during Archean time. The spectral analysis of these anorthositic rock will help in determining the similarities between lunar highland anorthositic rocks, also it will further help in understanding the genesis of anorthosites in terrestrial and in extraterrestrial objects. PRL members participated in Fieldwork: Anil Dutt Shukla, Amrita Dutt, Mudita Tater
PRL Members Participated in Fieldwork: Anil Dutt Shukla, Amrita Dutt, Mudita Tater

17. **Objective:** To sample the Banded Iron Formations (BIFs) from the Iron Ore Group occurring along the southern (Tomka-Daitari belt), western (Bonai-Keonjhar belt), and northern peripheries of the Singhbhum Granitoid

Complex. Sampling was conducted in the mines of Tomka, Kiriburu-Meghahatuburu, Joda-Noamundi, and Badampahar in Odisha.

PRL members participated in Fieldwork:
Duration: 11 March-20 March 2023
Type of fieldwork: Geological field work
Outcome: Iron isotopic studies in BIFs can provide insights into the composition and redox state of ancient (Precambrian) seawater, offering clues about early Earth's atmospheric and oceanic evolution. It will also indicate variations in microbial iron cycling processes, which will shed light on the role of microbial life in Earth's early oceans and their influence on iron deposition in BIFs. By comparing the isotopic signatures of iron minerals within BIFs to potential source rocks, such as volcanic or hydrothermal deposits, we can determine the provenance of the iron and infer the geological processes responsible for its deposition.
Implications Significance: Iron isotopic studies in BIFs can provide insights into the composition and redox state of ancient (Precambrian) seawater, offering clues about early Earth's atmospheric and oceanic evolution. It will also indicate variations in microbial iron cycling processes, which will shed light on the role of microbial life in Earth's early oceans and their influence on iron deposition in BIFs. By comparing the isotopic signatures of iron minerals within BIFs to potential source rocks, such as volcanic or hydrothermal deposits, we can determine the provenance of the iron and infer the geological processes responsible for its deposition.
PRL Members Participated in Fieldwork: Ambili Narayanan, Amrita Dutt, Shivansh Verma, Anil D. Shukla

18. **Objective:** Validation of Ocean Alkalinity Enhancement (OAE) for CO_2 removal (CDR)
Duration: 16-30 October 2023
Type of fieldwork: Mesocosm experiment at the Central Marine Fisheries Research Institute, Veraval, Gujarat
Outcome: We set up 10 mesocosm tanks, 1000 L each and provided with artificial light source. We selected two minerals - magnesite and olivine. Each mineral was added in four tanks in different concentrations to achieve a 10%, 20%, 30%, and 40% increase in total alkalinity, respectively, and the remaining two tanks served as controls. The salinity, temperature, and pH were measured in situ, whereas samples were collected for the measurements of alkalinity and DIC to see the effect of mineral dissolution on the CO_2 flux. We also aim to study the process of carbon and nitrogen fixation for which we did the incubation experiments using ^{13}C and ^{15}N tracers. To study the change in the phytoplankton community, we collected samples for DNA and flow cytometry analysisphytoplankton community, we collected samples for DNA and flow cytometry analysis.
Implications Significance: Our expectations are that this study will provide valuable insights into the effectiveness, risks, and feasibility of OAE as a CDR method. The story of mesocosm experiments are not just a tale of minerals and molecules but a narrative of hope, uncertainty, and the relentless pursuit of understanding the delicate balance between human activities and our planet.
PRL Members Participated in Fieldwork: Shreya Mehta, Himanshu Saxena, Nazirahmed Sipai, Jitender Kumar, Abul Qasim, Saloni Mishra and Arvind Singh

19. **Objective:** Understanding the high altitude soil carbon dynamics
Duration: 8-21 September 2023
Type of fieldwork: soil, soil and surface air, and stream water sampling
Outcome: Sample analysis is ongoing
Implications Significance: The study is to estimate the storage time of organic carbon in soils under cold climatic conditions and assess the impact of global warming on the emission of the major greenhouse gas CO_2 from the subtropical high altitude ($>$4000 m) cold soils of Himalaya. Also identification of the pathways of carbon loss is another objective of the study.
PRL Members Participated in Fieldwork: Bankimchandra Pandya, Rahul Kumar Agrawal, Ranjan Kumar Mohanty

20. **Objective:** Understanding tropical soil carbon dynamics
Duration: 21-28 January, 2024
Type of fieldwork: soil, soil and surface air sampling
Outcome: Sample analysis is ongoing
Implications Significance: The study is to estimate the turn-over time of tropical soil organic carbon and the factors governing it using stable isotopes and radiocarbon in soil organic carbon and soil CO_2. Also identification of the organic matter causing the major release of the soil CO_2 is another aim of the study.
PRL Members Participated in Fieldwork: Bankimchandra Pandya, Rahul Kumar Agrawal, Ranjan Kumar Mohanty

21. **Objective:** Understanding the Ganga water and groundwater interaction:
Duration: 29-31 July 2023
Type of fieldwork: River water and groundwater collection
Outcome: Sample analysis is ongoing
Implications Significance: A better understanding of the reasons for decreasing the flow rate in Ganga river particularly how the changes in the groundwater level influence the Ganga river water will help to better manage the river flow.
PRL Members Participated in Fieldwork: Amzad Hussain Laskar

22. **Objective:** Understanding the role of weathering on trace elements and isotopes
Duration: 26 August-26 September 2023
Type of fieldwork: Collection of water and sediment samples
Outcome: Sample analysis is ongoing
Implications Significance: The samples were collected to understand the impact of various processes (weathering, groundwater discharge, redox changes) on the supply of Mo and its isotopes to the river. Further, these samples will also be used to understand the weathering in the region using stable and radiogenic Sr isotopes.
PRL Members Participated in Fieldwork: Deependra Singh, Vineet Goswami

23. **Objective:** To understand the Archean and Precambiran atmosphere
Duration: 18 - 21 January 2024
Type of fieldwork: Samples collection
Outcome: To understand the Archean and Precambiran atmosphere.
Implications Significance: To understand the Archean and Precambiran atmosphere.
PRL Members Participated in Fieldwork: Yogita Kadlag

24. **Objective:** To study human-climate interactions in the mid-Holocene in the Uttarakhand Himalaya across the precipitation gradient
Duration: 13-28 April 2023

Type of fieldwork: Shallow cores from lake beds, optical chronology samples
Outcome: Sample analysis ongoing
Implications Significance: The study aims to develop an understanding of both the climate dynamics and the possible human interference across the precipitation gradient in the Central Himalaya
PRL Members Participated in Fieldwork: Shubhra Sharma

25. **Objective:** Carbon and nitrogen dynamics in the arctic fjords (Kongsfjorden and Krossfjorden,Svalbard)
Duration: 1-25 March 2024
Type of fieldwork: Sample collection of water from fjords and conducting tracer-based incubation experiments.
Outcome: Fieldwork conducted and samples in transit
Implications Significance: The study has the potential to improve our understanding of primary productivity and dinitrogen fixation in the arctic fjords.
PRL Members Participated in Fieldwork: Siddhartha Sarkar

Atomic, Molecular and Optical Physics

26. **Objective:** To extend dating limits
Duration: 1-5 August 2023
Type of fieldwork: Exploration and Sample Collection in Kutch, Gujarat
Outcome: The expected outcome will be the development of new technique for dating older samples
Implications Significance: It will help in the development of new techniques for dating millennium annum old samples
PRL Members Participated in Fieldwork: Dr. Naveen Chauhan and Ms. Malika Singhal

27. **Objective:** Exploration for new archaeological sites
Duration: 11-14 March 2024
Type of fieldwork: Field Exploration work around Sendrayanpalayam, Tamilnadu.
Outcome: New sites for studying human evolution
Implications Significance: Try to understand early human evolution in Indian context
PRL Members Participated in Fieldwork: Dr. Naveen Chauhan

Awards and Honors

Faculty

Anil Bhardwaj

1. Elected Fellow, Asia Oceania Geosciences Society (AOGS) 2023.
2. Elected Board of Trustee of the International Academy of Astronautics, Basic Sciences Section, for 2023-2025.
3. Awarded INSA Distinguished Lecture Fellowship, 2023.
4. Nominated Member, International Academy of Astronautics Commission 1 (Space Physical Sciences), 2023 2025 term.

M. M. Sarin

5. Member, United Nations Group of Experts on Scientific Aspects of Marine Environmental Protection (UN/GESAMP). GESAMP is an interagency advisory body of the United Nations.
6. Co-chair, United Nations/GESAMP Working Group on Climate Change and Greenhouse Gas Related Impacts on Contaminants in the Ocean sponsored by IAEA (Monaco) as lead agency.
7. Chair, INSA-National Committee (2024 26) of Intl SCOR (Scientific Committee on Oceanic Research).
8. Member, CSIR Expert/Monitoring Committee for NCP/FBR projects under the theme on Ecology, Environment, Earth, and Ocean Science & Water (E3OW).

Srubabati Goswami

9. Fulbright-Nehru Professional and Academic Excellence Fellow September 2023 - February 2024.

Duggirala Pallamraju

10. Member, Indian National Science Academy-International Science Council (INSA-ISC) for COSPAR, URSI, SCOSTEP for 2024-2026.
11. Chair, Core Committee to Review the Research Proposals to Indias 1^{st} Winter Expedition to Arctic (2023-2024).
12. Expert Committee Member, Team Selection Review Meeting, 43rd Indian Scientific Expedition to Antarctica (2024-2025).
13. Expert Committee Member, Team Selection Review Meeting, Indian Arctic Expedition (2024-2025).
14. Elected Corresponding Member, International Academy of Astronautics (IAA), Paris, 2023.
15. Member, Board of Studies, Department of Physics, MIT, World Peace University, Pune.
16. Chair (Alternate), Committee constituted by ISRO on Technical Review and Realization of the ISRO specific Instruments at Atmospheric & Space Research Facility (ASRF)", Balasore, Chandipur, Odisha.

Abhijit Chakraborty

17. Astronautical Society of India (ASI) award in Space Science and Applications for the year 2022.

Nandita Srivastava

18. Selected for ESAs Proba2 solar mission Guest Investigator (GI) funding on their proposal "Using SWAP Observations for Optimising the Magnetic Field Extrapolation and Solar Wind Velocity Prediction Models".

R. P. Singh

19. Elected Fellow, National Academy of Sciences in India (NASI) 2023. For pioneering contribution to experimental quantum optics and quantum cryptography. His outstanding experimental work includes the indigenous realization of free-space quantum key distribution. He has also contributed enormously to Indias national activities in the domain of quantum communication.
20. Editor of Special issue of Physics Open on Quantum Technologies- Fundamentals, State of Art and Prospects (Elsevier Publications).

Varun Sheel

21. Secretary, Indian Planetary Science Association.
22. Vice Chair, Commission B4: Terrestrial Planets, COSPAR, 16-21 April 2023, Nanyang Technological University, Singapore.
23. Member, Board of Studies at Amity Institute of Applied Sciences, Noida.

Debabrata Banerjee

24. Member, Technical Advisory Committee for Science, Technology and Innovation (STI) Policy Funds, GUJCOST (2019-till date).

B. K. Sahoo

25. Listed among the Top 2% of Scientists in the world in the respective research fields published in 2023 by Stanford University.
26. Elected Fellow, The National Academy of Sciences (NASI) in 2023.

G. K. Samanta

27. Editorial Board Member, Journal of Optics, IOP/
28. Guest Editor, Spotlight on India: Recent Advancements in Light-Matter Interaction, Journal of Physics B: Atomic, Molecular and Optical Physics, IOP, UK.

Kuljeet Kaur Marhas

29. Fulbright-Nehru Academic and Professional Excellence Award, United States-India educational foundation, 2022-23.

Som Kumar Sharma

30. Member, Board of Studies (BoS), Indian Institute of Remote Sensing (IIRS) ISRO, Dehradun.
31. Expert Committee Member of the Physics-English-Hindi-Gujarati vocabulary augmentation board under CSTT (Ministry of HRD).
32. Expert Committee Member, BEL (DRDO) Electronics vocabulary augmentation board under CSTT (Ministry of HRD).
33. Member, national committee for technical Review and Realization of the national project; "Atmospheric & Space Research Facility (ASRF)", Balasore, Chandipur, Odisha.
34. Member, Committee constituted by ISRO on Technical Review and Realization of the ISRO specific Instruments at Atmospheric & Space Research Facility (ASRF)", Balasore, Chandipur, Odisha.

Shashikiran Ganesh

35. Scientific High-Level Visiting Fellowship (SSHN - 2023) for a short research trip to France, awarded by the French Institute in India (IFI), French Embassy.

Lokesh Sahu

36. Member, expert committee of the Atmospheric Sciences for finalizing the teams for the Indian Arctic Expedition, Years: 2023 & 2024.
37. Nodal Faculty for Gujarat, the National Clean Air Programme (NCAP), Ministry of Environment, Forest & Climate Change (2019 to Present).
38. Member, Expert Group for Gujarat Pollution Control Board (GPCB), peer review of Emission inventory, Source Apportionment Study, and carrying capacity of concerned million-plus cities/non-attainment cities viz. Ahmedabad, Surat (2021 to present).

Neeraj Rastogi

39. Vice President of Indian Aerosol Science and Technology Association (IASTA) since Jan-2023.
40. Editorial Advisory Board, Asian Journal of Atmospheric Environment (Springer) since Jan-2020.
41. Nodal Faculty for Gujarat, the National Clean Air Programme (NCAP), Ministry of Environment, Forest & Climate Change since 2018.
42. Member, Board of Studies Committee for the Space and Atmospheric Science, Centre for Space Science and Technology Education in Asia and the Pacific, (CSSTEAP), United Nations since Sep-2021.
43. Guest editor, special issue on Carbonaceous Aerosols in the Atmosphere in the journal Aerosol and Air Quality Research (AAQR), 2023.

B. Sivaraman

44. Awarded a Visiting Fellowship in March 2024 to conduct experiments, at Aarhus Institute of Advanced Studies, Aarhus University from May-June, 2024.

J. P. Pabari

45. Member, Research Advisory Council, L. D. College of Engineering, Ahmedabad
46. Visiting Professor, CHARUSAT, Changa, Nadiad.
47. Member, Industry Advisory Board, E.C. Engg. Dept. of LDCE, Ahmedabad.
48. Member, Board of Studies at CSPIT, CHARUSAT, Changa, Nadiad.
49. Member of Doctoral Research Committee for Several Disciplines at GTU, Ahmedabad.
50. Member of Committee for Database of outside DPC Members at GTU, Ahmedabad, 2023-24.

Nishtha Anilkumar

51. Awarded the Vishwa Laxmi Best Librarian Award at the conference on Recent Trends in Academic Libraries" held during 18-19 August, 2023 organized by Manav Rachna Institute of Research and Studies (MRIRS), Faridabad.

K. Durga Prasad

52. Section Secretary, Planetary Sciences (PS) Section of Asia Oceania Geosciences Society (AOGS) for three years starting from 2023.

Arvind Singh

53. Indian National Science Academy (INSA) Associate Fellow (2023).

Naveen Chauhan

54. Member, Scientific Advisory Board for the Gemological Institute of India (GII), Mumbai.
55. Member, Scientific Advisory Board of the PALEOHER Foundation.
56. Member of the International organizing committee of LED-2023: 17^{th} International Luminescence and Electron Spin Resonance Dating Conference, Copenhagen, Denmark, 25 -30 June 2023.
57. Received INQUA-Financial grant for presenting work A Post Violet-Infrared Single Aliquot Regenerative (pVIR-SAR) Protocol, INQUA ROMA conference, Rome, Italy, 13-20 July 2023.

Amzad H. Laskar

58. Netherlands Earth System Science Centre awarded Dr. Amzad Laskar as eminent visiting scholar award 2023 for research collaboration with Utrecht University Netherlands.

Rishitosh Sinha

59. Eminent Alumni award in Science and Technology for the year 2023 from SRM University, Chennai.

XSM Team

60. Recipient, along with the CLASS payload team, of the “Zubin Kembhavi” award for Observational and Instrumentation work in Astronomy and allied fields, for the year 2023, conferred by the Astronomical Society of India for “Global elemental mapping of the lunar surface by payloads on Chandrayaan-2 orbiter”.

61. Astronomical Society of India Zubin-Kembhavi award for the year 2023 for Global elemental mapping of lunar surface by payloads of Chandrayaan-2. Team members: M. Shanmugam, Arpit R. Patel, Tinkal Ladiya, Shiv Kumar Goyal, Nishant Singh, Sushil Kumar, Deepak Kumar Painkra, Y. B. Acharya and Anil Bhardwaj.

Research Fellows

Yogesh

62. Member, E-SWAN (European Space Weather and Space Climate Association), 2023-2024.

Recognition, Best paper & Thesis awards

Faculty

Amit Basu Sarbadikari

1. Panellist, Discussion on Mars-context field expedition at the University of Kelaniya's (Colombo, Sri Lanka) Astronomy Student Society, 24 June 2023
2. Panellist, Discussion on Surface Science and Exploration of Venus, in the Venus Science Conference (Venus-SC 2023), 21-22 September 2023, PRL, Ahmedabad
3. Panellist, Discussion on Establishing a Flagship Space and Planetary Geoscience Research Program in Sri Lanka, Workshop at the Department of Geology, University of Peradeniya, Kandy, Sri Lanka, 28 June 2023

Amitava Guharay

4. SCOSTEP Scientific Discipline Representative (SDR) since June 2023
5. Served as a selection/interview committee member of Gujarat Science Academy best UG/PG teacher award in physical sciences on 28 August 2023

Anil Bhardwaj

6. Chairman, Science Working Group of Chandrayaan-3 Mission, 2023.
7. Chairman, Aditya-L1 Time Allocation Committee (ALTAC), 2023.
8. Member, Department Review Committee, Department of Astronomy, Astrophysics, and Space Engineering (DAASE), IIT Indore, 2023.
9. Chairman, Space Science and Technology Awareness Training (START) program, Training Content Review Committee, ISRO, May 2023.
10. Member, Selection Committee for IGU- Anni Talwani Memorial Prize for the year 2023
11. Chairman, NASI Ahmedabad Chapter, 2023
12. Member, AOGS Publication Committee, 2023-2025
13. Member, National Organising Committee of NSSS-2024, Goa, 26 Feb-1 March, 2024
14. President, Indian Planetary Science Association (IPSA), 2023 onwards.
15. Co-Convener, INSA Ahmedabad Chapter, 2024-2027.
16. Chief Guest, 2nd Convocation of Indian Institute of Information Technology, Surat, 19 August 2023.
17. Chief Guest, 3rd International Equatorial Plasma Bubbles Conference, IIG Navi Mumbai, 13 September 2023.
18. Chief Guest, 3rd International Conference on Plasma Theory and Simulations (PTS-2023), Jawaharlal Nehru University (JNU), New Delhi, 21 Sept 2023.
19. Chief Guest, Orientation Program, Indus University, 17 July 2023.
20. Chief Guest, SAL Institute of Technology and Engineering, 20 July 2023.
21. Chief Guest, National Convention of Chemistry Teachers, of Association of Chemistry Teachers Valedictory Session, GUJCOST-DST, Ahmedabad, 28 Oct. 2023.
22. Chief Guest, 162nd Birth Anniversary of Swami Vivekanand, Ramkrishna Mission, Hyderabad, 12 Jan. 2024.
23. Guest of Honour, St. Xavier College SciBlast Program Valedictory Function, Ahmedabad, 20 Jan. 2024.
24. Guest of Honour, NSSS-2024 Valedictory Function, Goa University, Goa, 1 March 2024

Arvind Singh

25. Editor: JGR: Oceans (an AGU journal) (July 2021 - present).
26. Member: AGUs Diversity and Inclusion Advisory Committee (2022-present).
27. Member: National Committee for Scientific Committee on Oceanic Research (SCOR, 2024-2027).
28. Steering Committee member of SOLAS (Surface Ocean Lower Atmosphere Study) (2022-2024).
29. Chaired a session on WCRP My Climate Risk (MCR) Lighthouse Activity on "Leveraging Climate.
30. Research and Modeling for Action in the Indo-Pacific region," on 29 September 2023 (online).
31. Chaired a session on Biogeochemistry session in the Samudra Manthan-23 1st National Oceanography Scholars' Meet during 28-30 September at NIO, Goa.

Bhuwan Joshi

32. Session Chair, 3rd Workshop of Belgo-Indian Network for Astronomy and Astrophysics (BINA) organized by ARIES, Nainital, 22-24 March 2023, Session Title: "MHD waves and small-scale transients."
33. Session Chair, 3rd International Conference on Plasma Theory and Simulations (PTS-2023), Jawaharlal Nehru University (JNU), New Delhi, 21-23 September 2023, Session Title: "Prof. S. Chandrasekhar young scientist award presentations."

34. Session Chair, ISRO Structured Training Program (ISRO-STP 2023) on "Sun-Planet Interactions: A Space Weather Perspective," PRL, Ahmedabad, 25-29 September, 2023.
35. Session Chair, Winter School on Concepts on Solar Physics, National Institute of Technology (NIT), New Delhi, 19-23 December, 2023.

Bijaya K. Sahoo

36. One of the organizers and lecturers of the ICTS program Introduction to Precision Measurements and Quantum Metrology held at ICTS, Bangalore from 10 - 21 July 2023.

Brajesh Kumar

37. Invited as an external examiner by the Mohan Lal Sukhadia (MLS) University, Udaipur, for conducting M.Sc. (Physics) Practical Examination of the Post Graduate Dept. of Physics, MLS University.

Dibyendu Chakrabarty

38. Moderator for Ionosphere and Radio Science at Venus Science Conference 2023 (Venus-SC 2023), Online Conference: 21-22 September 2023 at PRL
39. Reviewer, National Science Foundation (USA) research proposal
40. Member, COSPAR Task Group on International Geospace Systems Program (TGIGSP) since 2021
41. Invited Member, AGU Space Physics & Aeronomy Fellows committee (SPAFC) since 2022
42. Lead, RAMBHA-LP review team in the peer review committee for Chandrayaan-3 payload data, ISRO
43. Member, Payload Design Review Committee of DISHA Project, ISRO
44. Member, Scientific Organizing Committee (SOC), Workshop-1 (Aditya-L1: Indias Solar & Heliospheric Observatory in space), ASI-2024, 31 January 04 February, 2024 at IISc, ISRO and JNP, Bengaluru
45. Member, SOC, Beyond Aditya-L1: Exploring the future of Indian Solar Physics from Space, ARIES, Nainitaal, 07-09 November, 2023
46. Reviewer, CSIR-ASPIRE proposal, 2024
47. Guest of Honor at the Education Symposium, themed 'Higher Education & Realization of Sustainable Development: Paving the Way Forward,' organized by the Confederation of Indian Industry (CII) in association with Department of Higher Education, Government of West Bengal at The Taj Rajkutir, Swabhumi in Kolkata, 4 November 2023.

Duggirala Pallamraju

48. Panel Member, Panel Discussion on Opportunities and Challenges in Polar Studies, National Conference on Polar Studies, NCPS, 16 19 May 2023, NCPOR, Goa
49. Chief Guest, Staff Research Seminar, 18 April 2023, in St. Xaviers College, Ahmedabad.
50. Chair, Breakout Session, Aeronomy Mission held during National Space Science Symposium (NSSS-2024), 26 Feb to 1 Mar 2024, Goa University
51. Member, Payload Design Review Committee of DISHA Project, ISRO
52. Moderator for Atmospheres at Venus Science Conference 2023 (Venus-SC 2023), Online Conference: 21-22 September 2023 at PRL
53. Chair, Session 1 Advances in the experiments, techniques, and methods to monitor the EPBs, 3rd International workshop on Equatorial Plasma Bubbles (EPB-3)13 15 September 2023, Indian Institute of Geomagnetism, Navi Mumbai
54. Guest Editor for The Journal of Atmospheric and Solar-Terrestrial Physics special issue of SCOSTEP 15th Quadrennial Solar-Terrestrial Physics Symposium (STP-15), 2024.
55. Guest Editor for the Earth, Planets and Space (EPS), special issue, "16^{th} International Symposium on Equatorial Aeronomy (ISEA-16, 2022)".

Girjesh Gupta

56. Lead Investigator on "Waves and Oscillations in Sunspots with SUIT on-board Aditya-L1."

G. K. Samanta

57. The publication titled Simple experimental realization of optical Hilbert Hotel using scalar and vector fractional vortex beams has been featured by Scilight and selected as the Cover page of APL Photonics, Volume 8, Issue 6, June 2023.
58. The publication titled Dynamically tunable broadband output coupling of optical oscillators based on non-cyclic geometric phase mirror has been selected as Editors pick by APL Photonics, NOVEMBER 16 2023.

J. P. Pabari

59. Panelists of Two Scientific Discussions, Venus Science Conference (Venus-SC 2023), 21-22 September 2023, PRL, Ahmedabad.

K Venkatesh

60. Chair, working group -II.E (Ionospheric irregularities, Fields and waves) of International Association of Geomagnetism & Aeronomy-IAGA of IUGG (2023-present)
61. Co-convener, session A04 Advances in Mid-Latitude, Low-latitude and Equatorial Aeronomy in 28th IUGG General Assembly (IUGG 2023), 11-20 July 2023, Berlin, Germany

K. Durga Prasad

62. Convenor, Session on Surface Science and Exploration of the Moon and Airless Planetary Bodies (PS20) at 20th Annual meeting of Asia Oceania Geosciences Society (AOGS-2023) at Singapore.
63. Session Chair, Session on Science and Exploration of Mars and Venus (PS08-03), AOGS-2023.

Kuljeet Kaur Marhas

64. Nominated as committee member, Meteoritical Society 2023-2024
65. Co-PI, Analyses of Hayabusa-2 for presolar grains (JAXA)

Lokesh Kumar Dewangan

66. SOC member of the National conference,"Star Formation Studies in India" organized by the Department of Astrophysics and High Energy Physics of S.N. Bose National Centre for Basic Sciences, Kolkata India, during 8-11 January 2024.

    Session chair of "Interstellar Medium and Feedback" session in "Star Formation Studies in India", held at the Department of Astrophysics and High Energy Physics of S.N. Bose National Centre for Basic Sciences, Kolkata, India, during 8-11 January 2024.

Manash Samal

67. External examiner for Ph.D. thesis submitted to Indian Institute of Space Science and Technology (IIST), Thiruvananthapuram.

Md Nurul Alam

68. External expert member of R.D.C. of Ph.D. program in LIS at Monark University, Ahmedabad.

Megha Bhatt

69. Core team member of 2nd Forming and Exploring Habitable Worlds which is merged with the International Conference on Planets, Exoplanets, and Habitability for the year 2024.

Mudit K Srivastava

70. Best poster award in the category of "Facilities, Technologies and Data science" during 42nd Annual Meeting of Astronomical Society of India (ASI), held at Indian Institute of Science, Bengaluru, during 31 January - 04 February, 2024.

Namita Uppal

71. Best poster award for the poster titled "Revealing the Spiral Arms of our Galaxy towards the anti-centre direction: Insights from interstellar polarisation" in the "Stars, Interstellar Medium, and Astrochemistry in Milky Way" Category in the 42nd Annual Meeting of Astronomical Society of India (ASI), Indian Institute of Science, Bengaluru, 31 January-04 February, 2024.

Nandita Srivastava

72. Member, Aditya-L1 Time allocation Committee of ISRO
73. Guest Editor for The Journal of Atmospheric and Solar-Terrestrial Physics special issue of SCOSTEP 15th Quadrennial Solar-Terrestrial Physics Symposium (STP-15), 2024.
74. Chair, Plenary Session, at the Science of the ins-situ measurements from Aditya (SIMA) workshop, 11-13 April, 2023, SPL, Trivandrum.

Neelam JSSV Prasad, Rishikesh Sharma

75. Best poster award for the poster titled "From PARAS to PARAS-2 :A Journey towards super-Earths" in Plenary Session 4: Astronomy and Astrophysics of the 22nd National Space Science Symposium, Goa University, Goa, 26 February-1 March, 2024.

Neeraj Rastogi

76. Second prize for the platform presentation titled Role of meteorological conditions and sources influencing atmospheric NHx over a semi-urban site in north-western Indo-Gangetic Plain, in the conference organized by Indian Aerosol Science and Technology Association (IASTA-2023) at Vivanta, Navi Mumbai during 12-14 December 2023.
77. Member of Technical Programme Committee of the national conference organized by Indian Aerosol Science and Technology Association (IASTA) at Hotel Vivanta, Mumbai during December 12-14, 2023.
78. Chaired two sessions (1) Inaugural Invited Talks and (2) Health effects and Bioaerosols in the national conference organized by Indian Aerosol Science and Technology Association (IASTA) at Hotel Vivanta, Mumbai during December 12-14, 2023.

Neeraj Srivastava

79. External Examiner, M. Sc. Geology Practical examination, MG Science Institute, Gujarat University, 8th Nov. 2023

Nishtha Anilkumar

80. Subject expert for the recruitment of Library assistant at CSIR-NIO in May 2023

Pragya Pandey

81. External expert member of R.D.C. of Ph.D. program in LIS at Monark University, Ahmedabad.

R. P. Singh (AMOPH)

82. Guest of Honour for Convocation 2023, IIT Mandi

R P Singh (SPASC)

83. Member, Payload Design Review Committee of DISHA Project, ISRO

Ramit Bhattacharyya

84. Member of Scientific Organising Committee for Aditya-L1 Workshop-5 held at IIT Kanpur from 29th September to 1st October 2023.
85. Appointed as an external examiner for class M.Sc. Physics, IV Sem. for subject Practical - Astronomy and Astrophysics, Mohanlal Sukhadia University, Udaipur.

Rishikesh Sharma

86. Best poster award for the poster titled "Design and development of speckle imager for PRL 2.5m Telescope" in Modern Engineering Trends in Astronomy (META) Conference, Raman Research Institute (RRI), Bangalore, 1-4 November, 2023.

Rohan Eugene Louis

87. Sustained Heating of the Chromosphere and Transition Region Over a Sunspot Light Bridge (`https:/doi.org/10.3847/1538-4357/aca612`) featured as a NASA IRIS Science Nugget: `iris.lmsal.com/nugget?cmd=view-pod&pubDate=2023-04-13`

Sachindra Naik

88. External examiner for Ph.D. thesis submitted to (i) Indian Institute of Technology, Kanpur and (ii) Jawaharlal Nehru University, New Delhi
89. Member, Science Advisory Committee: Aryabhatta Research Institute of Observational Sciences, Nainital.

Sanjeev Kumar

90. Associate Editor, Frontiers in Marine Science (2016- present).

Som Kumar Sharma

91. Session Chair, ISGNS-2023, Symbiosis International University, Pune, 28-30 November 2023.
92. Judge for evaluation of best paper Award, ISGNS-2023, Symbiosis International University, Pune, 28-30 November 2023.
93. Session Chair, iRAD 2024, IIT Indore, 10-12 Jan 2024.
94. Committee Member, Evaluation of Best Poster Award, NSSS 2024, Goa, 26 February - 2 March 2024.

Srubabati Goswami

95. Included as Member, Membership Advisory Committee, TWAS 2023-2025.
96. Member, Editorial board for Journal of Physics G, IOP publications (2023-2024).
97. Member, Editorial board for the Journal Pramana (2023-2024).
98. Co-Chair IUPAP International Conference of Women in Physics held in online mode from 10-14 July 2023.
99. Member C11 commission of IUPAP (2023-24).

V.K.B. Kota

100. Selected as the top 2% scientists in the world in his field for career-long citations for the year 2022 as released by Stanford University in October 2023.
101. Selected as distinguished referee in 2023 by Euro Physics Journals (EPJ).

Varun Sheel

102. Convener of Session PS08: "Science and Exploration of Mars and Venus", 20th Annual meeting of the AOGS, Singapore, 30 July4 Aug. 2023
103. Co-convener of session PS04: Aeronomy and Plasma Physics of Planetary Evironments, 20th Annual meeting of the AOGS, Singapore, 30 July4 Aug. 2023
104. Session chair of PS20 - Surface Science and Exploration of the Moon and Airless Planetary Bodies, 20th Annual Meeting of the AOGS, Singapore, 30 Jul - 04 Aug 2023.
105. Session chair of PS08 - Science and Exploration of Mars and Venus, 20th Annual Meeting of the AOGS, Singapore, 30 Jul - 04 Aug 2023.

Veeresh Singh

106. External examiner for Ph.D. thesis submitted to Pandit Deen Dayal Upadhyay University Gorakhpur.

Research Fellows

Animesh Chatterjee

107. Member of the Publication committee of Short-Baseline Neutrino Experiment, Fermilab (2022-24).
108. Scientific Associate, CERN, September 2023-August 2024.

Anirban Ghosh

109. Received the best poster award for the paper, Experimental Observation of Optical Hilbert's Hotel in Vector Beam, 32^{nd} DAE-BRNS National Laser Symposium, RRCAT, Indore, 29 Jan - 1 Feb 2024.

Arijit Roy

110. Jon Hougen Memorial Award to Arijit Roy to attend the 77^{th} International Symposium on Molecular Spectroscopy, from June 17-21, 2024, at the University of Illinois, Urbana-Champaign, U.S.A.
111. Best Poster prize for the poster Shock Induced Formation of Mineral Dust in the Interstellar Space authored by Arijit Roy, V.S Surendra, M. Ambresh, J.K Meka, R. Ramachandran, D Sahu, S. Gupta V Jayaram, B.N. Rajasekhar, J Cami, Anil Bhardwaj, N.J. Mason, B Sivaraman, 60^{th} Annual Convention of Chemists (ACC), IIT Delhi, 20 - 21 December 2023.

Biswajit Mondal

112. The Justice Oak Award for Outstanding Thesis in Astronomy, 2023 (Honourable mention) by the Astronomical Society of India.

Dipali Singh

113. Best oral presentation award, International Conference on Planets, Exoplanets, and Habitability (ICPEH-2024), 5-9 Feb 2024, PRL, Ahmedabad.

Chahat Kaushik

114. Received the best poster award for the paper, Geometric phase induced tunable optimum output coupling in optical parametric oscillators, 32^{nd} DAE-BRNS National Laser Symposium, RRCAT, Indore, 29 Jan - 1 Feb 2024.

Kshitiz Upadhyay

115. Young Polar Scientist Award for the best presentation entitled, "Investigation of M-I coupling generated mid-latitude phenomena using ground-based OI 630.0 nm dayglow measurements" authored by Kshitiz Upadhyay and Duggirala Pallamraju in the National Conference on Polar Sciences (NCPS)-2023 held at National Center for Polar and Ocean Research (NCPOR), Goa during 16 - 19 May, 2023
116. Selected as a SCOSTEP Visiting Scholar (SVS) and visited Institute for Space-Earth Environment, Nagoya University, Nagoya, Japan during October-December 202

Mansi Gupta

117. Joint Secretary of the Early Career Scientist Network of International Indian Ocean Expedition-2 (IIOE-2-ECSN) from March 2022 to present

Megha Tomar

118. The Best Presentation Award in the PS3 session in the "National Space Science Symposium (NSSS 2024)" held at Goa University during 26 February -01 March 2024 for paper "Physical and mechanical properties of lunar soil at the landing site of Chandrayaan-3 mission" authored by Megha Tomar, Devyani Visana, Rishitosh K. Sinha, Snajay K. Mishra

Prabir Kumar Mitra

119. "2022 International Astronomical Union (IAU) PhD Prize Honorable Mention" for his PhD thesis entitled "Investigations of Initiation and Evolution of Transient Phenomena in Solar Atmosphere," supervisor: Bhuwan Joshi, Udaipur Solar Observatory (USO)

Ragav Ramachandran

120. Moderator of the Astrobiology and Exobiology session, 55^{th} Lunar and Planetary Science Conference, 11-15 March , 2024.

Sachana Sathyan

121. Best poster award, International Conference on Planets, Exoplanets, and Habitability (ICPEH-2024), 5-9 Feb 2024, PRL, Ahmedabad.

Sandeep Singh

122. Best Ph.D. thesis award for the thesis titled Generation and Characterization of Pair Photons for Quantum Sensing Applications by the Indian Lasers Association, 32^{nd} DAE-BRNS National Laser Symposium, RRCAT, Indore, 29 Jan - 1 Feb 2024.

Shubhendra Nath Das

123. Best oral presentation award for the presentation titled "Elevating Radial Velocity Precision: High-resolution spectroscopy with the Fabry-Perot wavelength calibrator" in International Conference on Planets, Exoplanets and Habitability (ICPEH), Physical Research Laboratory, Ahmedabad, 5-9 February, 2024.

Sovan Saha

124. COSPAR Outstanding Paper award for Young Scientist for the paper published in Advances in Space Research, entitled, Investigation of equatorial plasma bubbles as observed in the OI 630 nm nightglow emissions over off-equatorial and low-latitudinal locations over Indian longitudes authored by Sovan Saha, Duggirala Pallamraju, & Rupesh Ghodpage.

Sunil Kumar

125. Best presentation award for the oral presentation, entitled, A new approach to obtained three-dimensional daytime gravity waves authored by Sunil Kumar, Subir Mandal, and Duggirala Pallamraju at the 22nd NSSS-2024 hosted at Goa University, 26 Feb to 1 Mar 2024 Goa

Tejas Dave and Madan Fozia

126. Best Paper Award in GEOYOUTH-2024, organized at Mohanlal Sukhadia University, Udaipur, 56 March, 2024 for the paper titled Laboratory Reflectance spectroscopy of Sitampundi Anorthosite, A lunar analogue under the guidance of Neeraj Srivastava.

Vineet Rawat

127. Best poster award in the “Research Showcase Event, 2023 Cycle”, hosted by IIT-Gandhinagar on 27 July 2023.

Yogesh

128. Awarded a travel grant to attend E-SWAN (European Space Weather and Space Climate Association) School and ESWW-2023 (European Space Weather Week) at Toulouse, France, from 20-24 November 2023.

Human Resource Development

Human Resource Development at PRL

PRL has a strong Human Resource Development (HRD) component with Research Fellowship programme leading to PhD degree, Post-Doctoral and Visiting Scientist programs. In addition, PRL is having project training for graduate and post graduate students in both science and engineering. The purpose is to provide the students with an insight into current research activities being pursued at PRL which they can continue even after returning to their colleges/universities/institutes. It is also aimed at motivating them to take up research in basic sciences in their higher studies and career. Brief details of scientific output and staff in numbers during the reporting year are provided here

Research Fellowship Programmes

One of the important aims of the laboratory is to serve as a post-graduate and post-doctoral study centre in Physics, Earth & Planetary sciences and Chemistry to train research scholars in various aspects of experimental and theoretical research. With this in view, PRL offers a research fellowshop programme leading to Ph. D. degree. PRL provides opportunities for carrying out post-doctoral research. The strength of fellows under these programmes are presented in figure 1.

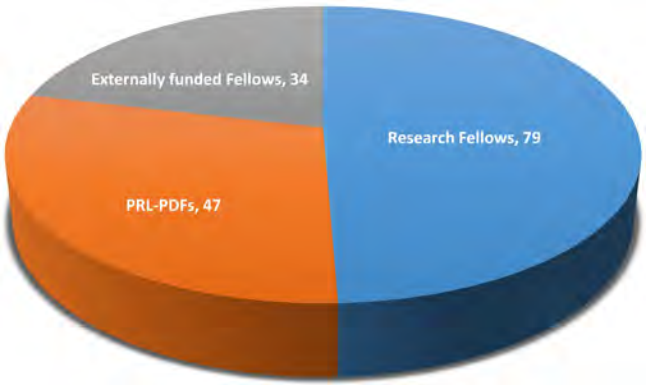

Figure 1: Research Programmes.

Research Programmes through Externally funded schemes

PRL encourages candidates with external funding from Government agencies such as DST, CSIR, NBHM, UGC, ISRO RESPOND, etc., to carry out their research in all campuses of PRL. Such candidates are governed by fellowship rules of the concerned funding agencies as applicable from time to time. Such candidates have an option to register for a Ph.D. degree in any of the institutes/universities with which PRL has an MoU, subject to their fulfilling the required eligibility criteria and course work requirements of the concerned university/Institute. Following table summarize the ongoing externally funded projects in PRL and figure 1 give statistics of the Research Scholars/PDFs/RAs in PRL including the ones employed through the externally funded projects.

Training Opportunities

PRL provides project training in engineering disciplines like computer engineering, electronics & communication, instrumentation & control, information technology to graduate/post-graduate students. Details of the same are presented in figure 2.

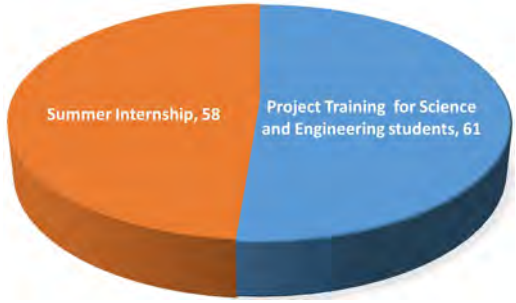

Figure 2: Internship Training Programmes.

PRL also offers training programmes in computers, electronics, library science, engineering and administrative services (Fig. 3).

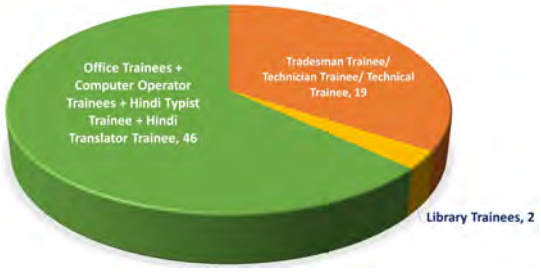

Figure 3: Training Programmes in technical and administrative areas.

Research Contributions

The research work carried out by PRL scientists are published in reputed and peer reviewed national and international journals. Several of our scientists are also invited to write review articles in the field

of their specialization. Some of our scientists have also edited books. Many of our scientists attended conferences and symposia at home and abroad where they present the results of their research investigations. Some of them are invited to present review talks. Few of them serve as chairpersons and Members of scientific committees for organizing national and International conferences and symposia. They are also invited to Convene and Chair sessions during symposia and meetings. The research output during the AY 2023-24 is shown in figure 4.

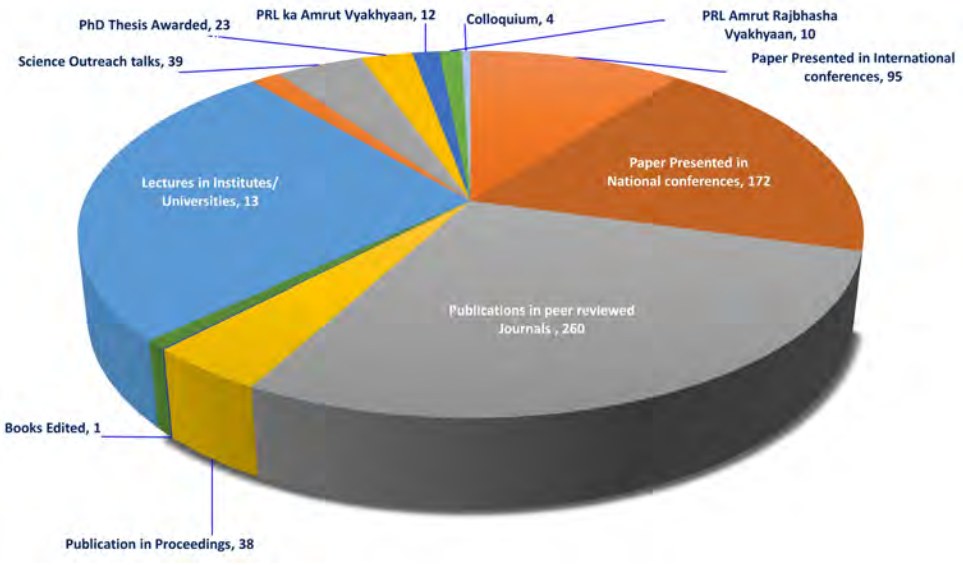

Figure 4: Research Contributions.

Administrative Support

Behind the scientific achievements of PRL is the able and efficient support given by the administrative and the technical staff. The administrative section of our laboratory continues to play an important role in providing an excellent management support to carry out our scientific activities. In addition, it also provides management support to the Solar Observatory at Udaipur and the Infrared Observatory al Mt. Abu. The staff structure of PRL is shown in figure 5.

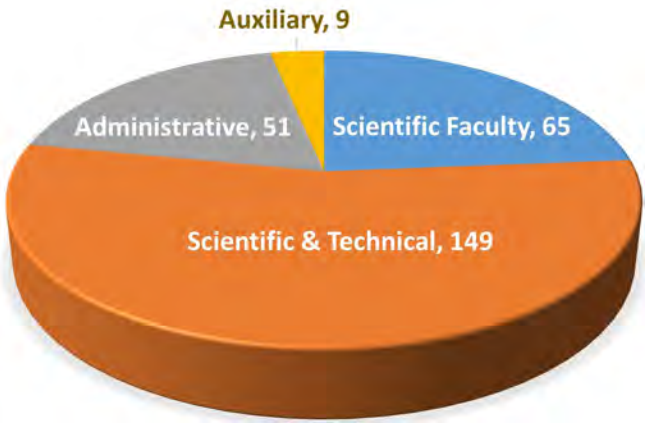

Figure 5: The distribution of PRL staff (as on 31 March 2024).

Research Fellowship Programme and Pre-PhD courses

PRL offers Junior Research Fellowships (JRFs) leading to a Ph.D. degree in the broad areas of ongoing research activities in PRL. Since inception of PRL around 500 research scholars have obtained their Ph.D. degree. PRL alumni have played a key role in the development of institutions and programmes in India and abroad. The Indian Space Research Organization (ISRO) was nucleated in PRL in the early seventies and two of the past ISRO Chairmen, Prof. U.R. Rao and Prof. K. Kasturirangan - are distinguished alumni of PRL.

After admission to PRL, each JRF needs to undergo a prescribed pre-Ph.D. course work prior to joining the research. In consideration of the requirements of (a) various Universities / IIT, where PRL research scholars register for their Ph.D. degree, and (b) University Grants Commission guidelines, two semesters of rigorous course work is offered to JRFs. In addition, JRFs are also required to do four projects as a part of their course work. In the year 2023-24, 14 new JRFs have joined PRL and 27 SRFs have been awarded Ph.D. degree.

Following is the list of courses offered to Junior Research Fellow of 2023 batch. Each course is of four credits and 40 hours of teaching.

Following is the list of courses offered to Junior Research Fellow of 2023 batch. Each course is of four credits and 40 hours of teaching.

Semester 1 courses

1. Writing-[Instructors: Dr. Bhushit Vaishnav & Mr. Anand Mehta]
2. Research Methodology-[Instructors: Dr. Arvind Singh & Dr. Shashi Prabhakar]
3. Review of Electrodynamics-[Instructors: Dr. Namit Mahajan]
4. Advanced Quantum Mechanics-[Instructors: Dr. Ketan Patel]
5. Advanced Statistical Mechanics-[Instructors: Dr. Paramita Dutta]
6. Fundamentals of Atmospheres and Climate-[Instructors: Dr. Shubhra Sharma & Dr. Narendra Ojha]
7. Application of Isotopes in Natural Science-[Instructors: Dr. Vineet Goswami & Dr. Amzad Hussain Laskar]
8. Tools and Techniques in Experimental Methods-[Instructors: Dr. Mudit Srivastava & Dr. T. A. Rajesh]
9. Remote sensing: Basics & Applications-[Instructors: Dr. S. Vijayan & Dr. Megha Bhatt]

Semester 2 courses

10. Radiative Transfer and stellar astrophysics-[Instructors: Dr. Aveek Sarkar & Dr. Arvind Singh Rajpurohit]
11. Astronomical Instrumentation and Fundamental Astronomy-[Instructors: Dr. Mudit Srivastava & Dr. Vishal Joshi]
12. Galactic and Extragalactic Astronomy-[Instructors: Dr. S. Naik & Dr. Veeresh Singh]
13. Star formation and Star Clusters-[Instructors: Dr. Lokesh Dewangan & Dr. Manash R. Samal]
14. Molecular Spectroscopy-[Instructors: Dr. Bhalamurugan Sivaraman]
15. Advanced Laser Science-[Instructors: Dr. Rajesh Kushwaha & Dr. Prashant Kumar]
16. Quantum Optics & Nano Photonics-[Instructors: Dr. Satyendra Gupta & Dr. Shashi Prabhakar]
17. Luminescence Physics-[Instructors: Dr. Naveen Chauhan & Dr. Vinayak]
18. Advanced stable isotopes and their applications in Earth Sciences-[Instructors: Dr. Amzad Laskar]
19. Upper atmosphere, ionosphere and space weather-[Instructors: Dr. Brajesh Kumar & Dr. Girjesh Gupta]
20. Solar Magnetohydrodynamics-[Instructors: Dr. Ramit Bhattacharyya]
21. The active Sun and space weather-[Instructors: Dr. Bhuwan Joshi]
22. Solar instrumentation-[Instructors: Dr. Rohan Eugene Louis]
23. Upper atmosphere, ionosphere and space weather-[Instructors: Dr. K. Venkatesh & Dr. D. Chakrabarty]
24. Physicochemical processes of trace gases, aerosols and atmospheric radiative transfer-[Instructors: Dr. L. Sahu & Dr. H. Gadhavi]
25. Dynamical, chemical and coupling processes in the Earth's atmosphere-[Instructors: Dr. A. Guharay & Dr. Som K. Sharma]

List of projects done by JRF of 2023 batch are as follows:

Rishav Sahoo

1. "Thermophysical Studies of Lunar Lava Tubes", Semester 1 project, from August 2023 to December 2023, [Supervisior: Dr. K Durga Prasad, Division: Planetary Sciences].
2. "Lab Reflectance Spectroscopy of Planetary Analogues", Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. Neeraj Srivastav, Division: Planetary Sciences].

Ritik Dalakoti

3. "Numerical Solution of Partial Differential Equations", Semester 1 project, from August 2023 to December 2023, [Supervisior: Dr Aveek Sarkar, Division: Astronomy and Astrophysics].
4. "Electric currents and magnetic reconnections in the heliosphere", Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr Aveek Sarkar, Division: Astronomy and Astrophysics].

Aishwarya Singh

5. “Establishment of a Radiocarbon Dating Technique using Zn-Fe graphite reduction method”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Dr. Amzad Hussain Laskar, Division: Geosciences].
6. “Establishment of a Radiocarbon Dating Technique using Zn-Fe graphite reduction method”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Dr. Amzad Hussain Laskar, Division: Geosciences].
7. “Molybdenum isotope ratios variability in headwaters of Yamuna River: Understanding the spatial variability and implications”, Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. Vineet Goswami, Division: Geosciences].

Ankita Chaurasia

8. “Study Of Aerosols Optical Properties Over An Urban Location”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Dr. TA Rajesh, Division: Space, Atmospheric, Molecular and Laser Physics].
9. “Study of Sudden stratospheric warming in MLT re”, Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. R P Singh, Division: Atomic, Molecular and Optical Physics].

Simrat Kaur

10. “Some perspective of radiative transfer in Solar physics”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Dr. Aveek Sarkar, Division: Astronomy and Astrophysics].
11. “A study of velocity oscillations in the quiet and magnetized solar photospheric regions using Fourier and Wavelet analysis”, Semester 2 project, from January 2024 to May 2024, [Supervisior: Dr. Brajesh Kumar, Division: Solar Physics].

Prashanth Kumar Kasarla

12. “Characterisation of Thorlabs polarisation sensitive camera”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Dr. Megha Upendra Bhatt, Division: Planetary Sciences].
13. “Design of collimator optics for the long range free space communication using QKD”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Prof. Ravindra Pratap Singh, Division: Space, Atmospheric, Molecular and Laser Physics].
14. “Variability of Stars or Asteroids using IRAF and Phython”, Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. Shashikiran Ganesh, Division: Astronomy and Astrophysics].
15. “Photometric data analysis”, Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. Vishal Joshi, Division: Solar Physics].
16. “Characterisation of Thorlabs polarisation sensitive camera”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Dr. Megha Upendra Bhatt, Division: Planetary Sciences].
17. “Design of collimator optics for the long range free space communication using QKD”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Prof. Ravindra Pratap Singh, Division: Space, Atmospheric, Molecular and Laser Physics].
18. “Variability of Stars or Asteroids using IRAF and Phython”, Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. Shashikiran Ganesh, Division: Astronomy and Astrophysics].
19. “Aperture Photometry using astropy in python”, Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. Vishal Joshi, Division: Astronomy and Astrophysics].
20. “Photometric data analysis”, Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. Vishal Joshi, Division: Astronomy and Astrophysics].
21. “Study on design of Optics and Detector systems for Terahertz Astronomy”, Semester 2 project, from January 2024 to April 2024, [Supervisior: Prof. Shashikiran Ganesh, Division: Astronomy and Astrophysics].

Hasil Dixit

22. “Understanding the Sun, Solar flare and Solar wind”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Dr. Girjesh Gupta, Division: Solar Physics].
23. “Study Of Coronal Loop Oscillations Using Wavelet transform.”, Semester 2 project, from January 2024 to April 2024, [Supervisior: Aveek Sarkar, Division: Astronomy and Astrophysics].

Dinesh Mishra

24. “Review of some topics in magnetohydrodynamics”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Prof. Namit Mahajan, Division: Theoretical Physics].
25. “Magnetic Reconnection and its manifestation in solar physics”, Semester 2 project, from January 2024 to May 2024, [Supervisior: Prof. Ramit Bhattacharyya, Division: Solar Physics].

Vaibhav Katyal

26. “Hartree-Fock Theory and its Application in Isotope shift studies”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Prof. B.K. Sahoo, Division: Atomic, Molecular and Optical Physics].
27. “Study on different pseudo random number generators”, Semester 2 project, from January 2024 to May 2024, [Supervisior: Prof. Goutam K Samanta, Division: Atomic, Molecular and Optical Physics].

Vishwa Vijay Singh

28. “Study of non-radial Solar wind”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Prof. Dibyendu Chakrabarty, Division: Space, Atmospheric, Molecular and Laser Physics].
29. “Image restoration from defocused images : MAST observations”, Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. A Raja Bayanna, Division: Solar Physics].

Anirban Ghosh

30. “Vortex generation in epsilon-near-zero materials”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Prof. R.P. Singh, Division: Atomic, Molecular and Optical Physics].
31. “Theory of Vector vortex beam generation in dielectric metasurfaces”, Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. Satyendra Nath Gupta, Division: Atomic, Molecular and Optical Physics].

Sanjan Roychowdhury

32. “Quadrature Measurement using Homodyne Detection”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Prof. R. P. Singh, Division: Atomic, Molecular and Optical Physics].
33. “Cavity Length Stabilization Using Lock-In + Pid Technique”, Semester 2 project, from January 2024 to April 2024, [Supervisior: Prof. Goutam K. Samanta, Division: Atomic, Molecular and Optical Physics].

Priyadarshee Priyattam Dash

34. “A Review on Accretion Discs”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Dr. Kinsuk Acharyya, Division: Planetary Sciences].
35. “Polarization Measurement in X - Ray Pulsars”, Semester 2 project, from January 2024 to April 2024, [Supervisior: Prof. Sachindra Naik, Division: Astronomy and Astrophysics].

Sonali Panda

36. “Exploration of Monte Carlo Tree Search Algorithm in the Context of Tic Tac Toe”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Dr. Partha Konar, Division: Theoretical Physics].
37. “Characterization of SF11 Material Properties via Femtosecond Pulse Analysis with SPIDER”, Semester 2 project, from January 2024 to May 2024, [Supervisior: Dr. Rajesh Kumar Kushawaha, Division: Atomic, Molecular and Optical Physics].

Aryan Kumar Nai

38. “Generation of Entangled Photons using Spontaneous Parametric down-conversion”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Prof. Goutam K. Samanta, Division: Atomic, Molecular and Optical Physics].

Shivam Parashar

39. “Ionospheric Irregularities, Radio Signals And Navigation”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Prof Dibyendu Chakrabarty, Division: Space, Atmospheric, Molecular and Laser Physics].
40. “Thermal Structure Of lower and middle Atmosphere”, Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. Amitava Guharay, Division: Space, Atmospheric, Molecular and Laser Physics].

Swagata Sarkar

41. “Theoretical Exploration of Vortex Beam Generation”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Prof. R.P Singh, Division: Atomic, Molecular and Optical Physics].
42. “Theoretical Exploration of Second Harmonic Generation”, Semester 2 project, from January 2024 to May 2024, [Supervisior: Prof. R.P Singh, Division: Atomic, Molecular and Optical Physics].

Aanchal Sahu

43. “Study of Impact and Escape Process on Moon”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Dr. Jayesh P. Pabari, Division: Planetary Sciences].
44. “Study of dust rings of Saturn”, Semester 2 project, from August 2023 to December 2023, [Supervisior: Dr. Jayesh P. Pabari, Division: Planetary Sciences].

Kushagra Srivastav

45. “Search for induced star formation in W5-W”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Dr. Manash Samal, Division: Astronomy and Astrophysics].
46. “Accretion mechanism in X ray binary system”, Semester 2 project, from January 2024 to April 2024, [Supervisior: Prof. Sachindra Naik, Division: Astronomy and Astrophysics].

Shipra

47. “An overview of Thermoluminescence and Optically stimulated luminescence”, Semester 1 project, from August 2023 to December 2023, [Supervisior: Prof. Debabrata Banerjee, Division: Planetary Sciences].
48. “Plasma Fireball sheath instability”, Semester 2 project, from January 2024 to May 2024, [Supervisior: Dr. Sanjay K. mishra, Division: Planetary Sciences].

Milan Jana

49. "Two-Photon Interference using Hong Ou Mandel Interferometry", Semester 1 project, from August 2023 to December 2023, [Supervisior: Prof. Goutam K. Samanta, Division: Atomic, Molecular and Optical Physics].
50. "Nano-structure Plasmonic Heating", Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. Satyendra Nath Gupta, Division: Atomic, Molecular and Optical Physics].

Antariksha Mitra

51. "Water Ice Detection on Rocky Bodies", Semester 1 project, from August 2023 to December 2023, [Supervisior: Dr. Debabrata Banerjee, Division: Planetary Sciences].
52. "Formation of Terrestrial Planets", Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. Kinsuk Acharyya, Division: Planetary Sciences].
53. "Understanding Planet Formation", Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. Kinsuk Acharyya, Division: Planetary Sciences].

Amit Chaturvedi

54. "Ionospheric and Plasmaspheric electron content variations over Ahmedabad using IRI-Plas model", Semester 1 project, from August 2023 to December 2023, [Supervisior: Dr. K. Venkatesh, Division: Space, Atmospheric, Molecular and Laser Physics].
55. "Statistical Properties of Superpenumbral Fibrils", Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. Rohan Eugene Louis, Division: Solar Physics].

Ayan Kumar Nai

56. "Quantum Random Number Generator", Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. Shashi Prabhakar, Division: Atomic, Molecular and Optical Physics].
57. "Characterizing a Heralded Single-photon Source measuring the Second Order Correlation Function", Semester 2 project, from January 2024 to April 2024, [Supervisior: Dr. Shashi Prabhakar, Division: Atomic, Molecular and Optical Physics].
58. "Generation of entangled photons using spontaneous parametric down-conversion", Semester 1 project, from August 2023 to December 2023, [Supervisior: Prof. Goutam K. Samanta, Division: Atomic, Molecular and Optical Physics].

Vaibhav Katyal

59. "Study on different pseudo random number generators", Semester 2 project, from January 2024 to April 2024, [Supervisior: Prof. Goutam K Samanta, Division: Atomic, Molecular and Optical Physics].

Status of Scheduled Caste/ Scheduled Tribe Personnel as on 31/03/2024

Centre/ Unit	Total Strength of Employees 2023-24	Strength of SC Employees	Strength of ST Employees	Strength of OBC Employees
PRL	274	12	07	58

Status of Differently Abled persons as on 31/03/2024

Centre/ Unit	Total Strength of Employees	Strength of Differently Abled Persons	Classification of employees with Disabilities			
			Deaf and Dumb	Blind	Partially Blind	Orthopedically Handicapped
PRL	274	5	1	0	0	4

Ph.D. Awarded

[Research work carried out at the Physical Research Laboratory by PRL Research Fellows/Project Associates/Employees towards Ph.D. degree]

Supriya Pan

1. "Probing Physics beyond the Standard Model in Neutrino Oscillation Experiments", Indian Institute of Technology, Gandhinagar, 03-02-2023, [Supervisor: Srubabati Goswami].

Amit Pandey

2. "Oxygen and Hydrogen Isotopic Characterization of Groundwaters of India: Insights into Hydrogeological Processes", Indian Institute of Technology, Gandhinagar, 02-03-2023, [Supervisor: R.D. Deshpande].

Shivani Baliyan

3. "Aqueous evolution of CM chondrites", Indian Institute of Technology, Gandhinagar, 03-04-2023, [Supervisor: Dwijesh Ray].

Rishitosh Kumar Sinha

4. "Glacial Landforms and gully formation on Mars", Indian Institute of Technology, Gandhinagar, 10-05-2023, [Supervisor: Dwijesh Ray].

Prakash Kumar Jha

5. "Iron oxide concretions from the Proterozoic Dhandraul (Vindhyan) sandstone: Implications for the origin of Martian hematite spherules", Indian Institute of Technology (Indian School of Mines), Dhanbad, 07-07-2023, [Supervisor: Dwijesh Ray].

Abhijit Kayal

6. "Population of Obscured Active Galactic Nuclei", IIT Gandhinagar, 17-07-2023, [Supervisor: Veeresh Singh].

Madhusudhan P

7. "Strong Field Ionization of Atoms and Molecules: An Ultrafast Perspective", IIT Gandhinagar, 28-07-2023, [Supervisor: Rajesh Kumar Kushawaha].

Milan Kumar Mahala

8. "Geochemical and isotopic studies of Sarnu-Dandali-Kamthai Carbonatite-Alkaline complex, India", Indian Institute of Technology, Gandhinagar, 29-07-2023, [Supervisor: J.S. Ray].

Abhay Kumar

9. "Hard X-ray spectro-polarimetric study of black hole binary Cygnus X-1", IIT Gandhinagar, 29-07-2023, [Supervisor: S. V. Vadawale].

Sana Ahmed

10. "Study of Cometary Coma: From Simple Molecules to Complex Organics", IIT Gandhinagar, 29-07-2023, [Supervisor: Kinsuk Acharyya].

Shanwlee Sow Mondal

11. "Energy transport in the solar atmosphere and Heliosphere", IIT Gandhinagar, 01-08-2023, [Supervisor: Aveek Sarkar].

Md. Atif Khan

12. "Spatial and Temporal Variations of Greenhouse Gases in Different Ecosystems", Gujarat University, Ahmedabad, 28-08-2023, [Supervisor: Sanjeev Kumar].

Anupam Ghosh

13. "Precision search for the new physics with hadronic final state at the LHC", Indian Institute of Technology, Gandhinagar, 26-10-2023, [Supervisor: Partha Konar].

Yogesh

14. "Investigations on the variations in helium abundance in the solar wind", Indian Institute of Technology, Gandhinagar, 09-11-2023, [Supervisor: Dibyendu Chakrabarty].

Namita Uppal

15. “Study of the Milky Way disk at different scales: Insights from red clump stars and open cluster polarimetry”, IIT Gandhinagar, 05-12-2023, [Supervisor: Shashikiran Ganesh].

Meghna Soni

16. “Modeling of Atmospheric Trace Gases over the Indian Subcontinent: Assessment of Chemical and Meteorological Processes”, Indian Institute of Technology, Gandhinagar, 06-12-2023, [Supervisor: Narendra Ojha].

Naval Kishor Bhadari

17. “Unveiling the Role of Interstellar Filaments in Massive Star Formation”, IIT Gandhinagar, 13-12-2023, [Supervisor: Lokesh Kumar Dewangan].

Dayanand Mishra

18. “Semi-leptonic B decays and QED effects”, Indian Institute of Technology, Gandhinagar, 14-12-2023, [Supervisor: Namit Mahajan].

Sunil Kumar

19. “Investigations of daytime upper atmospheric dynamics over low- and equatorial-latitudes”, Indian Institute of Technology, Gandhinagar, 29-12-2023, [Supervisor: Duggirala Pallamraju].

Akanksha Khandelwal

20. “Detection and Characterization of Transiting Giant Planets around Evolved Stars”, IIT Gandhinagar, 15-02-2024, [Supervisor: Abhijit Chakraborty].

Anju Rani

21. “Application of Polarisation and Phase in Quantum Information”, IIT Gandhinagar, 07-03-2024, [Supervisor: R. P. Singh].

Monika Devi

22. “Multispectral Luminescence Studies: Methodological Developments and Applications”, IIT Gandhinagar, 29-06-2024, [Supervisor: Naveen Chauhan].

Aravind K.

23. “Observational analysis of Cometary bodies in the Solar System”, IIT Gandhinagar, 29-07-2024, [Supervisor: Shashikiran Ganesh].

Special Talks, PRL ka Amrut Vyakhyaan (PKAV) & PRL Amrut Rajbhasha Vyakhyaan (PARV)

Colloquium

1. **Dr. Dimitra Atri**
   Group Leader, Mars Research Group, New York University Abu Dhabis Center for Space Science
   Exploring Mars With Hope 02 August 2023

2. **Prof. Bhanu Pratap Das**
   Director, Centre for Quantum Engineering Research and Education, TCG Centers for Research Education in in Science and Technology, Kolkata
   Quantum Computing: Applications in Atomic Physics 15 February 2024

3. **Prof. Martin Paetzold**
   RIU at Cologne University, Department Planetary Research, Cologne, Germany
   Radio Science Experiments with Interplanetary Spacecrafts 05 March 2024

4. **Prof. Marco Genovese**
   Research Director, The National Metrology Institute of Italy (INRiM), Italy
   Protocols of quantum imaging 20 March 2024

PRL ka Amrut Vyakhyaan

1. **Prof. Gopalan Jagadeesh**
   Senior Professor from the Department of Aerospace Engineering Indian Institute of Science, Bangalore
   Shocking waves - Healing touch! 19 April 2023 [PKAV]

2. **Wg. Cdr. Rakesh Sharma**
   Ashoka Chakra (Retd.)
   Future Space Exploration A Perspective 24 May 2023 [PKAV]

3. **Col. Christopher Rego**
   Founder and CEO, Sunbird
   Peace Through Education In North East India 14 June 2023 [PKAV]

4. **Prof. Mark Baskaran**
   Department of Environmental Science and Geology, Wayne State University, Detroit, MI.
   Human Impact on Global Climate Change Over the Past Two Centuries: Use of Isotope Tracing Techniques 19 July 2023 [PKAV]

5. **Prof. Subir Sarkar**
   Department of Physics, University of Oxford, United
   Seeing the high energy universe with IceCube 09 August 2023 [PKAV]

6. **Prof. Venu Gopal Achanta**
   CSIR-National Physical Laboratory (CSIR-NPL), New Delhi
   Metamaterials for light-matter interaction 27 September 2023 [PKAV]

7. **Prof. Manmohan Sarin**
   Physical Research Laboratory, Ahmedabad
   Five decades of marine and atmospheric aerosol chemistry research in PRL 31 October 2023 [PKAV]

8. **Prof. V. Ramaswamy**
   NOAA/Geophysical Fluid Dynamics Laboratory, and Professor, Atmospheric and Oceanic Sciences Program, Princeton University
   Planet Earth in Energy Imbalance: The Symptoms of Climate Change 17 November 2023 [PKAV]

9. **Prof. Balasubramanian Sundaram Sundaram**
   Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru
   Addressing Chemical Complexity Through Molecular Simulations 29 December 2023 [PKAV]

10. **Dr. Thamban Meloth**
    National Centre for Polar and Ocean Research, Ministry of Earth Sciences, Government of India, Goa
    Exploring Poles in a Warming World Indian Endeavours and New Frontiers 24 January 2024 [PKAV]

11. **Dr. Frank Pressuer**
    Institute of Earth and Environmental Sciences, University of Freiburg, Germany
    Seven decades of using luminescence in geochronology 21 February 2024 [PKAV]

12. **Prof. Ganapati D. Yadav**
    Institute of Chemical Technology, Mumbai.
    The Net Zero Goal & Sustainability: Green Hydrogen Technologies, CO_2 refineries, Biomass Valorization & Waste Plastic Recycling 14 March 2024 [PKAV]

PRL Amrut Rajbhasha Vyakhyaan

1. **Dr. Baldevanand Sagar**
   National President of World Sanskrit Media Council, Translator and Broadcaster of Sanskrit Manogatam of Prime Minister's "Mann Ki Baat" on All India Radio, Ministry of Information and Broadcasting, Government of India
   India's past, present and future 21 June 2023 [PARV]

2. **Dr. Harshil Mehta**
   Zonal Head, Emergency Medicine, Marengo Sims Hospital
   Stress Management 26 July 2023 [PARV]

3. **Dr. Shekhar Pathak**
   A founder of the People's Association for Himalayan Area Research, former Professor (History) at Kumaon University, Nainital,
   There is only one Himalaya 30 August 2023 [PARV]

4. **Dr. Abhay Kumar Thakur**
   Banaras Hindu University
   Financial Management Challenges 20 September 2023 [PARV]

5. **Dr. Shankar Kumar Parashar**
   Rajbhasha, Branch Secretariat, Department of Space, New Delhi
   Official Language Usage in Central Government Offices 04 October 2023 [PARV]

6. **Dr. Arvind C Ranade**
   Director, National Innovation Foundation, Gandhinagar
   Grassroot Innovation and Innovator Identity of Self-reliant India 30 November 2023 [PARV]

7. **Shri Sanjeev Chaturvedi**
   Chief Conservator of Forest (CCF), Haldwani, Uttarakhand
   Role of public servants and citizens in good governance and eradication of corruption 20 December 2023 [PARV]

8. **Dr. Satish Chandra Tripathi**
   Former Deputy Director General of the Geological Survey of India and General Secretary of The Society of Earth Scientists
   Status of geoheritage conservation and need to develop geoparks in India 17 January 2024 [PARV]

9. **Dr. Prem Chand Pandey**
   Director-NCPOR, Goa
   India: A rising power in the polar region 20 February 2024 [PARV]

10. **Prof. H.C. Verma**
    Indian Institute of Technology Kanpur
    My experiments in education field 06 March 2024 [PARV]

3rd Dr. Arvind Bhatnagar Memorial Lecture

1. Prof. Helen Mason OBE
University of Cambridge, UK.
Reaching for the Sun 29 November 2023

6th PRL-IAPT Dr. Vikram Sarabhai Lecture

1. Prof. Nigel Mason OBE
University of Kent, UK
The physicist in 21st century; applying fundamental knowledge 05 January 2024

4th Dr. Bibha Chowdhuri Memorial Lecture

1. Ms. Nandini Harinath
ISRO, Bangalore.
A sneak peek into few of ISROs prestigious missions 14 February 2024

Public Lecture

1. Prof. Michel Mayor, Nobel Laureate
University of Geneva, Switzerland.
Other worlds in the cosmos? The search for planets similar to earth and ...perhaps harbouring life!, 06 February 2024

Conference/Symposium/Workshop organized by PRL

Solar Physics

1. "USO/PRL Solar Physics Workshop [USPW-2023]", on "Multi Scale Phenomena on the Sun: Present Capabilities and Future Challenges", 03-05 April, 2023, at the Udaipur Solar Observatory.
2. "1st Winter School in Solar Physics at USO-PRL", 4-8 December 2023 at the Udaipur Solar Observatory.
3. "CSSTEAP short course on solar physics, 22-26 May, 2023", was held under the auspices of Center for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) affiliated to the United Nations, in online mode.

Planetary Sciences

4. "Venus Science Conference 2023", 21-22 September 2023, PRL, Ahmedabad.
5. "3^{rd} Meteoroids, Meteors and Meteorites: Messengers from Space Symposium", 1-3 Nov. 2023, PRL Ahmedabad.
6. "International Conference on Planets, Exoplanets, and Habitability", 5-9 Feb 2024, PRL, Ahmedabad.

Space and Atmospheric Sciences

7. "Space Weather science and opportunities", PRL, Ahmedabad 17 - 18 October 2023.
8. "2^{nd} Indian Space Weather Conference", PRL, Ahmedabad, 19 20 October 2023.

Geosciences

9. "Short Course on Isotopes in Nature", 7-9 March 2024, at PRL.

Theoretical Physics

10. "Annual Theory Discussion Days (ATDD-2023)", PRL, Ahmedabad, August 9-12, 2023.

Atomic, Molecular and Optical Physics

11. "4^{th} International Workshop on International Network in Space Quantum Technologies (INSQT)", 4^{th} International Workshop on International Network in Space Quantum Technologies (INSQT), Physical Research Laboratory, Ahmedabad, 20 -22 March 2024.
12. "Students Conference in Optics and Photonics(SCOP)", Students Conference in Optics and Photonics(SCOP), Physical Research Laboratory, Ahmedabad, 27-29 September, 2023..
13. "Vikram Discussions", Vikram Discussions(VD) -I on Astrobiology & Astrochemistry, Physical Research Laboratory, Ahmedabad, 5 - 6 January,2024.
14. "9^{th} Topical Conference on Ultrafast Photonics and Quantum Science", Physical Research Laboratory, Ahmedabad,15-17 February 2024.
15. "5^{th} Workshop on Luminescence Dating and its Application", 5^{th} Workshop on Luminescence Dating and its Application, organized by the Association of Luminescence Dating, Physical Research Laboratory, Ahmedabad, 21-23 February 2024.

Invited Talks at Conference / Symposia / Workshops

Astronomy and Astrophysics

Abhijit Chakraborty

1. “Discovery of two exoplanets with extreme densities with PARAS: TOI4603b and TOI1789”, Conference on Star Formation Studies, S. N. Bose National Centre for Basic Sciences, Kolkata, India, 8-11 January, 2024.
2. “The Legacy of EPRV at PRL”, International Conference on Planets, Exoplanets and Habitability (ICPEH), Physical Research Laboratory, Ahmedabad, 5 - 9 February, 2024.
3. “Exoplanet Sciences with PARAS-2 and PRL 2.5m telescope”, 22nd National Symposia for Space Sciences (NSSS), Goa University, Goa, 26th February - 01st March, 2024.

Santosh Vadawale

4. “Hard X-ray Spectro-Polarimetry for the Future Indian X-ray Polarimetry Mission”, 2nd XPoSat Users Meet, ISRO HQ, Bangalore, 8-19th December, 2023.
5. “X-ray Polarization from Black Hole X-ray Binaries: Prospects with POLIX”, 2nd XPoSat Users Meet, ISRO HQ, Bangalore, 8-19 December, 2023.
6. “X-ray studies of the solar atmosphere and Concept of future X-ray mission from space”, Beyond Aditya-L1: Exploring the future of Indian solar physics from space, ARIES, Nainital, 7-9 November, 2024.
7. “AstroSat and Beyond”, Sun- Planet Interactions: A Space Weather Perspective, PRL, Ahmedabad, 25-29 September, 2023.
8. “Black Hole X-ray Binaries: Observations with POLIX”, 1st XPoSat Users Meet, ISRO HQ, Bangalore, 25 May 2023.
9. “Solar Flares: Chandrayaan-2 XSM Experience and Aditya-L1 Perspective”, 1st Science from In-situ Measurements of Aditya-L1 (SIMA-01), pace Physics Laboratory, VSSC, Trivandrum, 11-13 April, 2023.
10. “Solar X-ray Spectral Monitoring with XSM onboard Chandrayan-2”, 51st meeting of the Space Weather Coordination Group, CGMS, Virtual, 27 April, 2023.
11. “X-ray studies of the solar atmosphere and Concept of future X-ray mission from space”, Beyond Aditya-L1: Exploring the future of Indian Solar Physics from Space, ARIES, Nainital, 07-09 November, 2023.

Sachindra Naik

12. “Polarimetric Observations of High Mass X-ray Binary Pulsars”, XPoSat User Meet, ISRO HQ Bengaluru, 18-19 December, 2023.

Shashikiran Ganesh

13. “PRL facilities for transient studies”, ASI Workshop, IISc Bengaluru, 31st Jan - 4th Feb, 2024.

Aveek Sarkar

14. “Particle Acceleration in Heliospheric shock”, 3rd Conference on Plasma Simulation, Indian Institute of Astrophysics, Leh, 13-15 July, 2023.
15. “Solar wind and heliosphere”, ISRO Structured Training Program (ISRO-STP 2023), PRL, Ahmedabad, 25-29 Sept, 2023.
16. “Science with ASPEX”, 5th Aditya-L1 Workshop, IIT, Kanpur, 29th Sept - 1st Oct, 2023.

Manash Samal

17. “Formation and early evolution of star clusters: the case of FSR 655 and NGC 2516”, Star Formation Studies in India, S.N. Bose National Centre for Basic Sciences, Kolkata, 8 -11 January, 2024.

Lokesh Kumar Dewangan

18. “Unearthing the hidden structures in star-forming regions: Results from JWST”, Star Formation Studies in India, S.N. Bose National Centre for Basic Sciences, Kolkata, 8-11 January, 2024.
19. “How do massive O-type stars form?”, Asia-Pacific Regional IAU Meeting 2023, Big Palette Fukushima in Koriyama, Japan, 7-11 August, 2023.

Arvind Singh Rajpurohit

20. “Exoplanets and earth-like exoplanets”, Space Science and Technology Awareness Training (START) programme, ISRO HQ, Bengaluru, June-July 2023.
21. “Exoplanets and Life Component”, YUva VIgyani KAryakram (YUVIKA-2023), Space Applications Centre (SAC), Ahmedabad, 17 May, 2023.

Ashok K. Singal

22. "Incongruency of dipole asymmetries seen in large radio surveys", Cosmology Workshop on A multi-polar universe?, Aristotle University of Thessaloniki, Greece, 4-7 September, 2023.

Mithun N. P. S.

23. "Prospects of Solar Flare Studies with Daksha", Daksha Science Workshop in 42nd meeting of Astronomical Society of India, IISc, Bangalore, 31 January - 04 February, 2024.
24. "The X-ray Sun: A Brief Introduction to Solar X-ray Astronomy", CSSTEAP short course on Solar Physics, PRL, Ahmedabad, 22-26 May 2023.

Abhijit Kayal

25. "Unveiling a new population of obscured Active Galactic Nuclei in deep field surveys", 42nd annual meeting of Astronomical Society of India, IISc, Bengaluru, 01-04 February, 2024.
26. "MIGHTEE radio continuum observations of AGN in dust-obscured galaxies", BCRS MIGHTEE symposium, University of Bristol, UK, 4-8 September, 2023.
27. "The Obscured AGN Population: Search and characteristics", Asia-Pacific Regional IAU Meeting 2023, Big Palette Fukushima in Koriyama, Japan, 07-11 August, 2023.

Aravind K.

28. "Unlocking the Mysteries of Comets: The Significance of Long-Term Monitoring through Spectroscopy and Photometry in Indian-Belgian Collaboration", BINA/BIPASS meeting, Brussels, Belgium, 10 October, 2023.

Sushant Dutta

29. "Remnant Radio Galaxies: Characteristics, Environment and Ages", Asia-Pacific Regional IAU Meeting 2023, Big Palette Fukushima in Koriyama, Japan, , 07-11 August, 2023.

Naval Kishor Bhadari

30. "New Insights into the Formation of Massive stars through End-dominated Collapse and Hub-filament systems in Filamentary Clouds", Asia-Pacific Regional IAU Meeting 2023, Big Palette Fukushima in Koriyama, Japan, 7-11 August, 2023.
31. "Dynamics of the inner environment of a hub-filament system hosting massive young stellar object W42-MME", Star Formation Studies in India, S.N. Bose National Centre for Basic Sciences, Kolkata, 8-11 January, 2024.

Akanksha Khandelwal

32. "Detection and Characterization of Exoplanets using PRL's high-Resolution Spectrographs", BINA/BIPASS 1-day workshop, Royal Observatory of Belgium, Brussels, Belgium, 10 October, 2023.

Arup Kumar Maity

33. "Unraveling signatures of cloud-cloud collision and hub-filament system toward massive star-forming regions: W31 complex, AFGL 5180, and AFGL 6366S", Asia-Pacific Regional IAU Meeting 2023, Big Palette Fukushima in Koriyama, Japan, 7-11 August, 2023.
34. "Origin of Hub-Filament Systems through Cloud-Cloud Collision", Star Formation Studies in India conference, S.N. Bose National Centre for Basic Sciences, Kolkata, 8-11 January, 2024.
35. "From Collision to Creation: Origin of Hub-Filament Systems through Cloud-Cloud Collision", 42nd annual meeting of Astronomical Society of India, IISc, Bengaluru, 01-04 February, 2024.

Solar Physics

Brajesh Kumar

36. "The Sun - structures and processes", ISRO-STP 2023 on Sun-Planet Interactions, PRL Ahmedabad, 25 - 29 September, 2023.
37. "Our Day-Time Star: The Sun", Workshop on Science Communication, Organized by National Council for Science & Technology Communication, Department of Science and Technology, Govt. of India, Mohanlal Sukhadia University, Udaipur (Rajasthan), 18 - 21 March, 2024.

Raja Bayanna

38. "Multi Application Solar Telescope : Instrumentation & Observations", USO Solar Physics Workshop (USPW-2023), USO, Udaipur, 3 - 5 April, 2023.

Girjesh Gupta

39. "Waves and oscillations in sunspots with SUIT", 3rd SUIT Science Meeting, IUCAA, Pune, 17 - 19 October, 2023.
40. "Solar Corona: Dynamics and Diagnostics", Beyond Aditya-L1: Exploring the future of Indian solar physics from space, ARIES, Nainital, 7 - 9 November, 2023.

Bhuwan Joshi

41. "Onset and evolution of solar flares: Application of 2D and 3D models of magnetic reconnection", Session on Physics of flares and CMEs, 3rd Workshop of Belgo-Indian Network for Astronomy and Astrophysics (BINA), ARIES, Nainital, 22 - 24 March, 2023.
42. "Unresolved Science of Solar Flares: Aditya-L1 Perspectives", 1st meeting on Science from In-situ Measurements of Aditya-L1 (SIMA-01), Space Physics Laboratory (SPL), Vikram Sarabhai Space Centre (VSSC), ThiruvananthapuramThiruvananthapuram, 11 - 13 April, 2023.
43. "Solar Flares: Evidence for 2D and 3D models of Magnetic Reconnection", Session on Space and Astrophysical Plasma, 3rd International Conference on Plasma Theory and Simulations (PTS-2023), Jawaharlal Nehru University (JNU), 21 - 23 September, 2023.
44. "Physics of Solar Flare", Solar Science with Aditya-L1, ISRO HQ, St. Joseph University (SJC), Bengaluru, 2 - 6 January, 2023.
45. "The Physics of Large-scale Eruptive Processes in the Solar Atmosphere", 3rd Aditya-L1 Support Cell Workshop, IIT (BHU), Varanasi, 25 - 27 February, 2023.
46. "Sun and Space Weather", Training Program for Secondary and Higher Secondary Teachers, Rajasthan State Institute of Educational Research and Training (SIERT, Govt. of Rajasthan), Udaipur, 18 - 20 April, 2023.
47. "Solar Physics and Space Weather: A Perspective", Workshop on "Multidisciplinary Approach to Understand the Mysteries of our Universe, National Institute of Technology (NIT), Rourkela, 17 - 21 July, 2023.
48. "Solar Flares", ISRO Structured Training Program (ISRO-STP 2023) on "Sun-Planet Interactions: A Space Weather Perspective", PRL, Ahmedabad, 25 - 29 September, 2023.
49. "Solar Eruptive Phenomena: Origin and Interplanetary Consequences", 12th Faculty Induction Program, UGC-HRDC, Banaras Hindu University (BHU), 10th October, 2023.
50. "Solar Flares and Associated Phenomena", Winter School on Concepts of Solar Physics, National Institute of Technology (NIT), Delhi, 19 - 23 December, 2023.

Ramit Bhattacharyya

51. "CME initiation and its characteristic evolution in the low corona", ASI 2024 Workshop 3 - CME propagation in the interplanetary space to predict Bz and space weather impact, Bangalore, 31st Jan, 2024.

Rohan Eugene Louis

52. "Sustained Heating of the Chromosphere and Transition Region Over a Sunspot Light Bridge using MAST Observations", USO Solar Physics Workshop, USO, Udaipur, 4th April, 2023.

Kushagra Upadhyay

53. "Ground based solar radio observation in india", USO-PRL Solar Physics Workshop (USPW-2023), USO, Udaipur, 3 - 5 April, 2023.

Nandita Srivastava

54. "National ISWI Activity", ISWI Steering Committee Meeting, Vienna, 5 - 6 February, 2024.
55. "Coronal Mass Ejections (CMEs) and their impact on Space Weather", International symposium titled: "From the Universe Back to Earth; Developing Astronomy to Meet Today's Natural Challenges" on 100 years of Bosscha Observatory, Indonesia, 3 - 7 October, 2023.
56. "India-Uzbekistan Collaboration in Astronomy: From medieval to recent times", International conference on "Ali Qushji An outstanding ambassador of the scientific school of Ulugh Beg" celebrating the 620th anniversary of Ali Qushjis birth and the 80th anniversary of the Uzbekistan Academy of Sciences, Uzbekistan, 21 - 22 September, 2023.
57. "Coronal Mass Ejections", ISRO-STP workshop on Sun-Planet Interactions: A Space Weather Perspective, PRL, Ahmedabad, 25 - 29 September, 2023.
58. "CME-CME interaction & its in-situ signatures", SIMA, SPL, Trivandrum, 11 - 13 April, 2023.
59. "Filaments dynamics such as oscillations and instability", 3rd SUIT science meeting organised by IUCAA, IUCAA, Pune, 17-19 October, 2023.
60. "CMEs and space weather", Online CSSTEAP Short Course on Solar Physics, PRL, Ahmedabad, 23 - 27 May, 2023.

Planetary Sciences

Amit Basu Sarbadhikari

61. "Establish a Flagship Space and Planetary Geoscience Research Program in Sri Lanka.", Workshop at the Department of Geology, University of Peradeniya, Kandy, Sri Lanka., 28 June 2023.
62. "Geological history/formation of Mars", 3^{rd} Meteoroids, Meteors and Meteorites: Messengers from Space Symposium, PRL Ahmedabad, 01-03 November 2023.
63. "Geochemical evolution of Mars", Online talk delivered as part of prioritizing science themes for the future Mars Landing Mission, ISRO, 23 February 2024.
64. "Planetary Differentitation", CSSTEAP Short-Course on "Planetary Sciences", PRL Ahmedabad, 15-19 May 2023.
65. "Study of planetary samples in Lab", 3^{rd} Post Graduate Course in Space and Atmospheric Sciences, CSSTEAP, PRL, 28 November 2023.

Anil Bhardwaj

66. "Planetary Space Weather: Sun-Planet Connection", First meeting of Science from In-situ Measurements of Adtya-L1 (SIMA- 01), SPL-VSSC, Trivandrum, 11-13 April, 2023.
67. "Sun-Planet Connection", National Conference on Polar Sciences, National Centre for Polar and Ocean Research, Goa, 18 May 2023.
68. "Indian Space Program", 65^{th} European Space Science Committee Plenary Meeting, Lisbon, 6 June 2023.
69. "Indian Lunar Program", European Lunar Symposium, Padua, Italy, 27 June 2023.
70. "Indian Lunar Exploration Program", 20^{th} AOGS Annual Meeting, Singapore, 1 August 2023.
71. "Planetary Exploration program of India", 3^{rd} International Equatorial Plasma Bubbles conference, IIG Navi Mumbai, 13 Sept. 2023.
72. "Indian Planetary Exploration program", 3^{rd} International Conference on Plasma Theory and Simulations, JNU, New Delhi, 21 Sept 2023.
73. "INSA Distinguished Lecture", 89^{th} INSA General Anniversary Meeting, NGRI-CCMB-IICT, Hyderabad, 6 Dec.2023.
74. "Indian Planetary Missions", 42^{nd} Astronomical Society of India Annual Meeting, IISc, Bangalore, 01 Feb. 2024.
75. "Planetary Missions of India", International Conference on Planets, Exoplanets and Habitability, PRL Ahmedabad, 5-9 Feb 2024.
76. "Scientific Achievements from Indian Lunar Missions", 22^{nd} National Space Science Symposium, Goa University, Goa, 28 Feb. 2024.
77. "The Solar System", CSSTEAP Short-Course on "Planetary Sciences", PRL Ahmedabad, 15 May, 2023.
78. "Current and future space science missions", Talk at DAKSHA workshop, ASI-2024, IISc, Bangalore, 31 Jan, 2024.

Debabrata Banerjee

79. "Formation, Evolution and Present State", ISRO START Program, ISRO, July 2023.
80. "X-ray, γ-ray Spectroscopy of Planetary Bodies", CSSTEAP Course on Planetary Science, PRL Ahmedabad, May 2023.

Dipak Kumar Panda

81. "Instrumentation for Luminescence Reader", 5^{th} Workshop on Luminescence Dating and its application, PRL Ahmedabad, 20-23rd February 2024.

Dwijesh Ray

82. "Terrestrial impact craters: The good and the bad", Short course under CSSTEAP programme, PRL Ahmedabad, May 22, 2023.

Jayesh P. Pabari

83. "Electromagnetic Wave Propagation in Ionosphere", Short course under CSSTEAP programme, PRL Ahmedabad, 6-11 November, 2023.
84. "Venus Mission", ISRO Structural Training Program, PRL Ahmedabad, 29 September 2023.
85. "Interplanetary Dust and Space Weather", ISRO Structural Training Program, PRL Ahmedabad, 27 September 2023.
86. "Metallic ion layer in Venusian atmosphere", Venus Science Conference, PRL Ahmedabad, 22 September 2023.

K. Durga Prasad

87. "Thermophysics of the Moon through finite element simulations", COMSOL International Conference, Bangalore, 30 Nov- 1 Dec, 2023.
88. "Perspectives of Thermophysics and Volatiles on the Moon", 3^{rd} Meteoroids, Meteors and Meteorites: Messengers from Space Symposium, PRL Ahmedabad, 1-3 Nov, 2023.

Kinsuk Acharyya

89. "Importance of Low-temperature Chemistry in Astrophysical Environments", Recent Trends in Chemical Science and Technology, IIT Patna, 1- 2 March, 2024.
90. "Minor Bodies in the Solar System Asteroids, Comets and Meteors", Space Science Technology & Awareness Training, ISRO, 31 July, 2023.

Kuljeet Kaur Marhas

91. "Interstellar heritage and birth of the Early solar system", 3^{rd} Meteoroids, Meteors and Meteorites: Messengers from Space Symposium, PRL Ahmedabad, 1-3 Nov, 2023.

M. Shanmugam

92. "Aditya Solar wind and Particle Experiment In situ particle measurements", USO-PRL Solar Physics Workshop, PRL Ahmedabad, 3 April, 2023.
93. "Aditya Solar wind and Particle Experiment", Science from In-situ Measurements of Aditya-L1 (SIMA-01), SPL/VSSC, Thiruvananthapuram, Kerala., 11th April, 2023.
94. "APXS on-board Chandrayaan-3 Rover: The first in-situ elemental composition measurement on lunar south pole", 3^{rd} Meteoroids, Meteors and Meteorites: Messengers from Space Symposium, PRL Ahmedabad, 1-3 Nov, 2023.

Megha Bhatt

95. "Airless Planetary Bodies of our solar system", CSSTEAP course on Planetary Science, PRL Ahmedabad, 17 May, 2023.
96. "Effects of space weather on airless bodies like Moon", ISRO-STP, PRL, Ahmedabad, 27 September, 2023.

Neeraj Srivastava

97. "Overview of Lunar Geology", 3^{rd} Meteoroids, Meteors and Meteorites: Messengers from Space Symposium, PRL, Ahmedabad, 1-3 Nov, 2023.

S. Vijayan

98. "Solar System Planets, their Satellites, and other Minor Bodies", UN Course under the PRL CSSTEAP program, SAC, Ahmedabad, 17-20 October 2023.

Rishitosh Sinha

99. "Atmospheres of planets and satellites", UN Course under the PRL CSSTEAP program, SAC, Ahmedabad, 17-20 October, 2023.

Varun Sheel

100. "Planetary Science and Exploration - An Indian Perspective", World Space Week 2023, Indian Institute of Technology-Roorkee, 10 October, 2023.
101. "Climate of Mars - Role of Mathematics", 60^{th} Annual Conference of Gujarat Ganit Mandal, Ahmedabad, 21 November 2023.
102. "Science from Current and Future Missions to Mars, Venus and Moon", PS-05 (Enabling technologies for space exploration), 22^{nd} National Space Science Symposium, Goa, 26 February 01 March 2024.
103. "Role of Dust and Photochemistry in Climate of Mars", IIRS Academia Meet, Dehradun, 18-19 March 2024.
104. "Space Weather at Mars and Venus", ISRO Structured Training Program (ISRO-STP 2023) on Sun-Planet Interactions: A Space Weather Perspective, PRL Ahmedabad, 25-29 September 2023.
105. "Planetary Atmospheres", Online short course on Planetary Science, under the CSSTEAP programme, PRL Ahmedabad, 15-19 May 2023.
106. "Atmospheres of Terrestrial Planets in the Solar System", Space Science and Technology Awareness Training (START) programme of ISRO, ISRO, 28 July 2023.

S. A. Haider

107. "An overview of Science and Explorations of Indian Planetary missions", Short visit, American University of Sharjah (AUS), 10 May 2023.
108. "Analysis and modeling of EMM data", Presented by S. A. Haider and Tariq Majeed, UAE Space Agency, 18 May 2023.
109. "An overview of Science and Explorations of Indian and Emirates Planetary missions", Seminar organized by Sharjah Academy for Astronomy, Space Sciences, and Technology, University of Sharjah, 17 May 2023.

Space and Atmospheric Sciences

Duggirala Pallamraju

110. "An overview of Space Weather science and its effects on Space Applications", SATMET-13 Course conducted by UN-CSSTEP hosted by Space Application Center, SAC, Ahmedabad, 4 Sept 2023.
111. "Recent developments on the precursors to plasma bubbles", 3^{rd} International workshop on equatorial plasma bubbles (EPB-3), Indian Institute of Geomagnetism, Mumbai, 13-15 Sept 2023.
112. "Potential of Equatorial Plasma Bubble studies using in situ and remote sensing payloads of DISHA", 3^{rd} International workshop on equatorial plasma bubbles (EPB-3), Indian Institute of Geomagnetism, Mumbai, 13-15 Sept 2023.
113. "Overview of Space Weather", Workshop on Space Weather Science and opportunities, PRL, Ahmedabad, 17 18 Oct 2023.
114. "Evolution of Space Weather Research at PRL and in India", Workshop on Space Weather Science and opportunities, PRL, Ahmedabad, 17 18 Oct 2023.
115. "ISROs Aeronomy Satellite mission DISHA (Disturbed and quiet time Ionosphere- thermosphere System at High Altitudes)", 2^{nd} Indian Space Weather Conference, PRL, Ahmedabad, 19 20 Oct 2023.
116. "Aurora and airglow tracers of Space Weather", 34^{th} Mid-Year Meeting, Indian Academy of Sciences, Indian Academy of Sciences, Bengaluru, 7 8 July 2023.
117. "On modelling framework for future atmosphere-ionosphere system research", Brainstorming meeting for discussing the road map for a unified modelling framework for future atmosphere-ionosphere system research, National Atmospheric Research Laboratory, Gadanki, 28 Aug 2023.
118. "Impacts of Space Weather", ISRO-Structured Training Program (ISRO-STP 2023) on Sun-Planet Interactions: A Space Weather Perspective, PRL, Ahmedabad, 25 29 Sept 2023.
119. "DISHA Mission", ISRO-Structured Training Program (ISRO-STP 2023) on Sun-Planet Interactions: A Space Weather Perspective, PRL, Ahmedabad, 25 29 Sept 2023.
120. "Ionosphere-thermosphere investigation of planet earth", International Conference on Planets, Exoplanets and Habitability, PRL, Ahmedabad, 5 9 Feb 2024.
121. "Space Weather Effects and Challenges of Forecasting", Advanced training for Meteorological Officers (ATMOS), Air Force Academy, Hyderabad, 14 Feb 2024.

S Ramachandran

122. "Aerosols and Climate Impacts", UN-CSSTEAP Satellite Meteorology and Global Climate Post-Graduate Course, SAC, Ahmedabad, 6 Sept 2023.
123. "Sun-Climate Interactions", ISRO-Structured Training Programme, PRL, Ahmedabad, 25 29 Sept 2023.
124. "Recent trends in restoration of Ecosystem (Keynote Addres)", HRDC Refresher Course, Madurai Kamaraj University, Madurai, 15 Nov 2023.

125. "Climate Change: Issues and Challenges", HRDC Refresher Course, Madurai Kamaraj University, Madurai, 15 Nov 2023.
126. "Aerosols and Climate Change: Challenges", Workshop on Space-based GreenHouse Gases, Air Quality and Climate Change, National Remote Sensing Centre, Hyderabad, 20-21 Dec 2023.
127. "Aerosols and Climate Change: Challenges", International Conference on Sustainable Development Goals (SDGS 2024), University of Hyderabad, 18-20 Jan 2024.
128. "Aerosols over South Asia", National Workshop on Land, Atmosphere, and Ocean Response to North East Monsoon (NawNEM 2024), Sathyabama Institute of Science and Technology, Chennai, 22-23 Feb 2024.
129. "Light-absorbing Aerosols and Radiative Forcing", University of Puerto Rico-Rio Piedras, San Juan, Puerto Rico, USA, 25 Mar 2024.

Dibyendu Chakrabarty

130. "Capturing solar wind through ASPEX instrument in Aditya L1 mission", (Invited Talk), University of Engineering & Management, Kolkata, 8 Mar, 2024.
131. "Reaching for the Sun through Aditya-L1", National Science Day, PRL, Ahmedabad, 6 Mar 2024.
132. "Aditya Solar Wind Particle Experiment (ASPEX)", Aditya-L1: Indias Solar & Heliospheric Observatory in space, 42^{nd} ASI-2024, IISc, Bengaluru, 31 Jan - 4 Feb 2024.
133. "ICME and impact on Magnetosphere-Ionosphere system", CME propagation in the interplanetary space to predict Bz and space weather impact, 42^{nd} ASI-2024, IISc, Bengaluru, 31 Jan - 4 Feb 2024.
134. "Understanding Sun, solar wind and space weather through Aditya Solar wind Particle Experiment (ASPEX) on-board Aditya L1 mission", 9^{th} India International Science Festival (IISF), Indian Institute of Geomagnetism, Mumbai, 26 Dec 2023.
135. "Solar wind: Composition, properties and processes", Winter School on concepts in Solar Physics, NIT-Delhi, 19-23 Dec 2023.
136. "Impact of solar wind on magnetosphere-ionosphere system", Winter School on concepts in Solar Physics, NIT-Delhi, 19-23 Dec 2023.
137. "Understanding the Sun and Space weather processes through Aditya solar wind Particle EXperiment (ASPEX) on-board Aditya-L1 mission of India", First Winter School on Solar Physics, PRL, USO Udaipur, 4-8 Dec 2023.
138. "Solar Wind and Solar Energetic Particles", Beyond Aditya-L1: Exploring the future of Indian Solar Physics from Space, ARIES, Nainital, 7-9 Nov 2023.
139. "Aditya Solar wind Particle EXperiment (ASPEX)", 2^{nd} Indian Space Weather Conference (ISWC-2), PRL, Ahmedabad, 19 20 Oct 2023.
140. "High Frequency Augmented Langmuir Probe (LP)", 2^{nd} Indian Space Weather Conference (ISWC-2), PRL, Ahmedabad, 19 20 Oct 2023.
141. "Airglow photometer (AP)", 2^{nd} Indian Space Weather Conference (ISWC-2), PRL, Ahmedabad, 19 20 Oct 2023.
142. "Solar wind and magnetosphere", Workshop on Space Weather Science and Opportunities (ISWC-2 [2023]), PRL, Ahmedabad, 17 18 Oct 2023.
143. "Solar wind and magnetosphere", ISRO Structured Training Program (ISRO-STP 2023) on Sun-Planet Interactions: A Space Weather Perspective, PRL, Ahmedabad, 25 29 Sept 2023.
144. "Aditya-L1 mission", ISRO Structured Training Program (ISRO-STP 2023) on Sun-Planet Interactions: A Space Weather Perspective, PRL, Ahmedabad, 25 29 Sept 2023.
145. "Solar wind measurements by Aditya-L1: What can the messengers from the Sun reveal to us?", 3rd International Conference on Plasma Theory and Simulations (PTS-2023), Jawaharlal Nehru University (JNU), New Delhi, 21-23 Sept 2023.
146. "Sun-Planet interaction and Space weather", CSSTEAP Online short course on Solar Physics, PRL, USO Udaipur, 22-26 May 2023.
147. "Aditya Solar Wind Particle Experiment", Science from In-situ Measurements from Aditya-L1 (SIMA-01), Space Physics Laboratory, VSSC, Thiruvananthapuram, 11-13 April 2023.
148. "The story of Helium in solar wind", USO Solar Physics Workshop (USPW-2023) entitled "Multi-scale Phenomena on the Sun: Present Capabilities and Future Challenges, PRL, USO Udaipur, 3-5 April 2023.

Yogesh

149. "Enrichment of Helium abundance in Interplanetary Coronal Mass Ejections: Insights", 41^{st} Annual Meeting of the Astronomical Society of India (ASI), IIT Indore, 1-5 March 2023.

Jacob Sebastian

150. "ASPEX/STEPS Science, Instrument and Data Analysis", 6^{th} Aditya-L1 Science Support Cell Workshop, JECRC University, Jaipur, 6-8 Feb 2024.

Abhishek Kumar

151. "ASPEX/SWIS Science, Instrument and Data Analysis", 6^{th} Aditya-L1 Science Support Cell Workshop, JECRC University, Jaipur, 6-8 Feb 2024.

Som Kumar Sharma

152. "Lower and Middle Atmospheric Processes, Clouds, Boundary Layer and Long-term changes in the Atmosphere", Recent Research Trends in Atmospheric Science Focusing on the Tropospheric Layer over India, ISRO Headquarters, Bengaluru, 22 February 2023.
153. "Role of Ground and Satellite Based Remote Sensing in improving Atmospheric models", Satellite Meteorology and its Application in Numerical Weather Prediction, 15 March 2023, NESAC, Shillong.

154. "Atmospheric Investigations of Clouds and Boundary Layer Characteristics using LIDAR", Department of Physics, University of Dibrugarh, University of Dibrugarh, Dibrugarh, 17 March 2023.
155. "Comprehensive Investigations of the Atmospheric Boundary Layer: Scientific and Societal Perspectives", National Workshop on Boundary Layer Exchange Processes and Climate Change (NoBLExClim 2023), SRM Institute of Science and Technology (SRMIST), Chennai, 23-24 March, 2023.
156. "Investigations of Atmospheric Boundary Layer, Clouds, and Pollutants under Using PRLs Lidar Network", 2^{nd} International Conference on the Asian Summer Monsoon Anticyclone (ASMA)-2023, SRM Institute of Science and Technology (SRMIST), Chennai, 11-13 September 2023.
157. "Atmospheric Investigations using Remote Sensing: Role of Indian Lidar Network (ILIN) Program", National Symposium on Exploring Geospatial Ecosystems, Trends, and Innovation (ISGNS-2023), Symbiosis International University, Pune, 28-30 November 2023.
158. "LIDAR A versatile atmospheric Remote Sensing Instrument", 6^{th} Conference on India Radar Meteorology (iRAD-2024), IIT, Indore, 10-12 January 2024.
159. "Investigation of Cloud and Boundary Layer, using PRLs LIDAR Network", Physics Department, DDU University, DDU University, Gorakhpur, 7 March 2024.
160. "Radars/Lidars for clouds characterization and ABL studies", Capacity building workshop on 'Space Technology Applications to Study Climate Change & its Impact, NESAC, Shillong, 11-22 March 2024.
161. "Aerosol-cloud interaction and its impact on climate change", Capacity building workshop on 'Space Technology Applications to Study Climate Change & its Impact, NESAC, Shillong, 11-22 March 2024.

Lokesh Kumar Sahu

162. "Understanding of emission and atmospheric processes of reactive trace gases over the Indian subcontinent and surrounding oceanic regions: A synthesis of comprehensive field measurements", National Space Science Symposium 2024, Goa University, Goa University, Goa, 26 February to 1 March 2024.
163. "Impacts of reactive trace gases on atmospheric composition and air quality over South Asia and importance of satellite-based observations", 2-Day National Brainstorming Workshop on Space-based Greenhouse Gases, Air Quality and Climate Change, National Remote Sensing Centre, Hyderabad, 20-21 December 2023.
164. "Impact of convection in the vertical distributions of reactive trace gases over India: Role of ENSO events", 2^{nd} International Conference on the Asian Summer Monsoon Anticyclone Gateway of surface pollutants to the stratosphere (ASMA 2023), SRM Institute of Science and Technology (SRMIST), Chennai, 11-13 September 2023.
165. "Transport and local sources of atmospheric non-methane hydrocarbons in the sub-Himalayan region of India during winter", National Conference on Polar Sciences (NCPS-2023), NCPOR, Vasco-da-Gama, Goa, 16-19 May 2023.

Harish Gadhavi

166. "Ozone layer and climate change: Interlinked by science and optimism", World Ozone Day, Indian Meteorological Society, Ahmedabad Chapter, SAC, Ahmedabad, 15 September 2023.

R P Singh

167. "Introduction to Ionosphere, Thermosphere, and Airglow emissions", Workshop on Space Weather Science and Opportunities, PRL, Ahmedabad, 17 18 October 2023.

K Venkatesh

168. "Effects of ionospheric irregularities on the performance of GNSS systems over the low latitudes", 3^{rd} International workshop on equatorial plasma bubbles (EPB-3), Indian Institute of Geomagnetism, Mumbai, 13-15 September 2023.
169. "Longitudinal and hemispheric variabilities of the low latitude ionospheric dynamics and space weather effects", Conference on Frontiers in Space and Atmospheric Sciences (COFSAS-2023), Institute of Astronomy Space and Earth Science, Kolkata, 15-16 March 2023.
170. "Ionosphere and Space Weather", ISRO Structured Training Program (ISRO-STP 2023) on Sun-Planet interactions: A space weather perspective, PRL, Ahmedabad, 25 29 September 2023.
171. "Ionospheric dynamics and implications to satellite navigation", Workshop on space weather science and Opportunities, PRL, Ahmedabad, 17 18 October 2023.

Narendra Ojha

172. "Impact of monsoon on atmospheric composition over south Asia: Combining observations with model results", 2^{nd} International Conference on the Asian Summer Monsoon Anticyclone (ASMA-2023), SRM Institute of Science and Technology (SRMIST), Chennai, 11-13 September 2023.

Geosciences

M. M. Sarin

173. "Sources, characteristics and atmospheric deposition of Black Carbon over Himalayan glaciers: Environmental Implications", National workshop on "Impact of Climate Change on water resources of Upper Indus River Basin- An UIBN initiative", Department of Earth Science, University of Kashmir, Srinagar (J & K), 01- 02 May 2023.
174. "Atmospheric Brown Carbon over northern India: Sources, characteristics and climate implications", Conference on Mountain Ecosystem Processes and Sustainable Livelihood, G B Pant National Institute of Himalayan Environment, Kullu (Himachal Pradesh), Mar 5 - 7, 2023.

J. S. Ray

175. "Carbonatites of Deccan Large Igneous Province, in Deccan Next 2023", International conference on Deccan Traps, SVP University, Pune, Oct 2-5, 2023.

R.D. Deshpande

176. "Water Resources of the Upper Indus Basin: An Integrated Earth System Approach", National Workshop on Impact of Climate Change on Water Resources of Upper Indus Basin, India: A UIBN-IC initiative, at Srinagar, Kashmir, organized by The Department of Earth Sciences, University of Kashmir in association with Ministry of Earth Sciences (MoES), GoI, Department of Science and Technology (DST), GoI and Indian Institute of Magnetism (IIG) Mumbai, Indian Institute of Geomagnetism, Mumbai, 1-2 May, 2023.
177. "Frontiers of Research for Hydrological Problems", ISRO Sponsored National Natural Resources Management System (NNRMS) training program for university teachers/ professors and scientists, Indian Institute of Remote Sensing (IIRS), Dehradun, 26 June, 2023.
178. ""Isotope Applications for Glaciological Studies and its importance for Hydrological Problems Distinguished Resource", Person Lecture delivered on 15 September, 2023, in a 3-week Capacity Building Program/School in Glaciology, Centre of Excellence for Glacial Studies, University of Kashmir, Srinagar, 11-30 Sept, 2023.
179. "Water Resource Problems of India: Importance of Isotope Fingerprinting", Part of the Structured Training Programme (STP-2023), PRL, Ahmedabad, 26 September 2023.
180. "Imminent Challenges in Himalayan Mountain Ecosystem: Importance of multi-disciplinary fundamental research", International Conference Mountain Ecosystem Processes and Sustainable Livelihood, Himachal Regional Centre (HRC) of G.B. Pant National Institute of Himalayan Environment (NIHE), Kullu, Himachal Pradesh, 5-7 March 2024.

Sanjeev Kumar

181. "The Nitrogen Paradox", National Centre for Polar and Ocean Research, Goa, NCPOR, Goa, 23 August 2023.
182. "Too much or too little: the story of nitrogen", National Institute of Oceanography, Goa, NIO, Goa, 28 Sep 2023.
183. "Too much or too little: the story of nitrogen", A public lecture, Indian Institute of Science Education and Research, Trivandrum, 10 February, 2024.

Neeraj Rastogi

184. "Sources and Processes affecting Air Quality in Ahmedabad: Implications to Human Health", Workshop on Clean Air for Ahmedabad: Stakeholder Consultation for Mitigation Strategies organized by Ahmedabad Municipal Corporation (AMC) and World Resources Institute (WRI), Hotel Fortune Landmark, Ahmedabad, February 29th, 2024.
185. "Deeper Insights into Sources and Processes Affecting Ambient Carbonaceous Aerosols using Dual Carbon Isotopes", National Atmospheric Chemistry Seminar Series (NACSS), Indian Institute of Tropical Meteorology (IITM), Pune, November 3rd, 2023.
186. "Environmental Effects of Ambient Aerosols in Fast Reactor Aerosol Research: Current Scenario and Future Directions (FARAR 2023)", Conference organized by Indira Gandhi Centre for Atomic Research (IGCAR)g, Anupuram, Tamil Nadu, October 26-27, 2023.

Arvind Singh

187. "Can Ocean Alkalinity Enhancement help to remove atmospheric CO_2?", INSA Annual Meeting at NGRI/IICT/CCMB, Hyderabad, Hyderabad, 6 December 2023.

Amzad Hussain Laskar

188. "Clumped isotopes in ice core air O_2: reconstruction of past atmospheric oxidant levels", Meeting at Utrecht University, Netherlands, Meeting at Utrecht University, Netherlands, 12 September, 2023.

Vineet Goswami

189. "Stable Mo isotopes δ^{98}Mo : Applications towards understanding the earth system processes", Symposium on recent advances in Aquatic geochemistry, IISER Pune, India, 22 April 2023.

Shubhra Sharma

190. "Resource person talk in 5th Luminescence Dating", Workshop on Time-stamping the Quaternary glaciation in Himalaya, PRL, Ahmedabad, 21-23 Feb, 2024.

Theoretical Physics

Partha Konar

191. "Deep Learning in Particle Physics", WHEPP 2023, IIT Gandhinagar, 2 - 11 Jan, 2024.
192. "Deep Learning", International Conference PHOENIX-2023, IIT Hyderabad, 18 - 20 Dec, 2023.
193. "Deep Learning", International Conference ICHEPAP 2023, SINP, Kolkata, 11 - 15 Dec, 2023.

Paramita Dutta

194. "When waiting time matters for superconducting junctions", STATPHYS Kolkata XII, SNBNCBS, Kolkata, 18 - 22 Dec, 2023.
195. "Bogoliubov Fermi Surfaces: connection to exotic Cooper pairs and transport signatures", Young Investigators Meet on Quantum Condensed Matter Theory (YIMQCMT 2023), IISER Bhopal, 14 - 17 Dec, 2023.
196. "When waiting time matters for superconducting junctions", Annual Conference on Quantum Condensed Matter (Q-MAT 2023), NISER, Bhubaneswar, 27 - 30 Nov, 2023.
197. "When waiting time matters for superconducting junctions", Condensed Matter Meets Quantum Information, ICTS, Bengaluru, 25 Sep - 06 Oct, 2023.
198. "When waiting time matters'", Annual Theory Discussion Days (ATDD) 2023, PRL, Ahmedabad, 09 - 11 Aug, 2023.

Satyajit Seth

199. "Does subtraction work at NLP?", Annual Theory Discussion Days (ATDD) 2023, PRL, Ahmedabad, 09 - 11 Aug, 2023.
200. "NLP corrections to H+jet production", WHEPP 2023, IIT Gandhinagar, 2 - 11 Jan, 2024.
201. "Soft and Next-to-soft corrections: a novel approach", Advanced School and Workshop on Multi-loop Scattering Amplitudes, NISER, Bhubaneswar, 15 -19 Jan, 2024.

Animesh Chatterjee

202. "Opportunity to search for the BSM physics at the ICARUS detector", LLP13 Conference, CERN, Geneva, 19 - 23 Jun, 202.

Library & Information Services

Nishtha Anilkumar

203. "Recent Trends in Academic Libraries", International Conference on Recent Trends in Academic Libraries, Manav Rachna Institute of Research and Studies (MRIRS), Faridabad, 15 - 19 August 2023.

Atomic, Molecular and Optical Physics

R. P. Singh

204. ""Free Space Quantum Communication"", World Quantum Day, Indian Institute of Science Education and Research, Kolkata, India, 14 April, 2023.
205. "Free Space Quantum Key Distribution: India and the World", International Conference on Quantum Information and Quantum Technology (QIQT-2023), Indian Institute of Science Education and Research, Kolkata, India, 8 May, 2023.
206. "Free Space Quantum Communication: Road to Satellite Quantum Communication", QuEST Theme-1, 2^{nd} Workshop, CSK Himachal Pradesh Agriculture University, Palampur, 13-14 May, 2023.
207. "Using Entangled Photons for Quantum Communication and Sensing", International Symposium on Quantum Computing and Innovations (ISQCI) -2023, IIT BHU Campus, Varanasi, 14-15 July, 2023.
208. "Free Space Quantum Key Distribution", Raman Conference on Light and Matter Physics, RRI Bangalore, 14 - 18 August, 2023.
209. "Free Space Quantum Communication: Achievements and Challenges", Workshop on Quantum and Nonlinear Optics: Opportunities and Challenges, Optics and Photonics Centre, I.I.T. Delhi, 29 December, 2023.
210. "Free Space Quantum Communication", ATAL FDP program, R V College of Engineering, Bangalore, 21 December, 2023.
211. "Free Space Quantum Communication: Road to Satellite Quantum Communication A Review", BOSE Stat@100, The International Conference on Photonics, Quantum Information and Quantum Communication (ICPQIQC), S. N. Bose National Centre for Basic Sciences, Kolkata, 29 Jan 02 Feb, 2024.
212. "Challenges in Implementation of Free Space Quantum Communication", Second International Quantum Communication Conclave (2^{nd} IQCC), Organized by Telecommunication Engineering Centre in collaboration with C-DOT and TSDSI, Vigyan Bhavan, New Delhi, 15-16 February, 2024.
213. "Experiments in Free Space Quantum Communication", National Workshop on Quantum Technologies (NWQT-2024), Department of Physics, Institute of Science, Banaras Hindu University, Varanasi, 01-02 March, 2024.
214. "Quantum Science and Applications", Structured Training Program on Quantum Technologies & Communication, Space Application Centre, Ahmedabad, 18-22 March, 2024.

G. K. Samanta

215. "Full Poincare beam: generation, characterization, and applications to represent Hilbert Hotel paradox", Complex Light and Optical Forces XVIII,SPIE Photonics West, The Moscone Center, San Francisco, CA, USA, 27 January - 1 February, 2024.
216. "Structured beams for the experimental realization of Hilbert Hotel paradox", International Conference on Optics, Photonics and Quantum Information (OPTIQ-2023), Cochin University of Science and Technology, Kochin, India, 11-13 December, 2023.
217. "Quantum sensing using high brightness heralded single-photon source", Quantum Information Processing and Applications (QIPA-2023), Harish-Chandra Research Institute (HRI), India, 04-10 December, 2023.
218. "Full Poincare beams: realization of Hilbert Hotel paradox", Physics seminar, Indian Institute Of Technology Delhi (IIT Delhi), 6 November, 2023.
219. "Spatial structured optical beams: Linear and nonlinear optical studies", ICFO-TIFRH International School on The Frontiers of Light, Tata Institute of Fundamental Research(TIFR), Hyderabad, 25 -27 October, 2023.

220. "Robust, bright photon sources for quantum communication and quantum sensing applications", Physics Colloquium, Indian Institute Of Technology (IITMadras), Madras, 13 September, 2023.
221. "Hong-Ou-Mandel interferometry based quantum sensor: Photonics", Hong-Ou-Mandel interferometry based quantum sensor: Photonics, Indian Institute of Science (IISc), Bangalore, 5 - 8 July, 2023.
222. "Structured optical beams for the experimental implementation of Hilbert's Hotel paradox", The "International Day of Light" celebration, Indian Institute of Technology Ropar (IIT Ropar), 16 May, 2023.
223. "Quantum sensing using Hong-Ou-Mandel Interferometer", Summer School on Quantum Information and Quantum Technology - 2023 (QIQT-2023), Indian Institute of Science Education and Research (IISER), Kolkata, 8 May 15 June, 2023.

Bhalamurugan Sivaraman

224. "Laboratory Astrochemistry", 60^{th} Annual Convention of Chemists, Indian Institute Of Technology Delhi (IIT Delhi), 22 December, 2023.

Rajesh Kumar Kushawaha

225. "Ultrafast lasers and applications", Workshop on Atomic and Molecular Physics, Inter University Accelerator Centre (IUAC), New Delhi, 14-15 September, 2023.
226. "Ultrafast laser applications: Quantum Control in Molecules (yield control with attosecond delay)", DAE-BRNS Theme Meeting on Ultrafast Science (UFS-2023), CSIR-National Physical Laboratory, New Delhi, 25-27 November, 2023.
227. "Quantum Control of Molecular Photo-Dissociation in the Two-Color Laser Field: Attosecond Delay", International Conference on Condensed Matter and Device Physics - 2023 (ICCMDP-2023),(Session chair), Pandit Deendayal Energy University (PDEU), Gandhinagar, 27-29 September, 2023.

Naveen Chauhan

228. "Luminescence Dating and its Application", Preworkshop Training in The 5^{th} Workshop on Luminescence Dating and its Application, Physical Research Laboratory, Ahmedabad, 21-23 February 2024.

Prashant Kumar

229. "Preparing flyable payloads", 1^{st} Vikram Discussion on Astrobiology and Astrochemistry, Physical Research Laboratory, Ahmedabad, 5-6 Jan 2024.
230. "Detecting organics through laser-induced breakdown spectroscopy", 1^{st} Symposium on Organics In Space, IIST, Thiruvananthapuram, 18-20 Jan, 2024.

Shashi Prabhakar

231. "Position momentum entanglement", Summer School on Quantum Information and Quantum Technology 2023 (QIQT-2023), Indian Institute of Science Education and Research Kolkata (IISER-K), 19 May, 2023.

Arijit Roy

232. "Fate of Organics and Organometallics behind the Shock Front", 1^{st} Symposium on genesis and evolution of organics in space organized by IIST., Indian Institute of Space Science and Technology (IIST) , Trivandrum, 18-20 January, 2024.

Ragav Ramachandran

233. "S+ Ion Irradiation of Aspartic acid: A case study for the conversion of N-containing amino acid to S-containing amino acid in Space", 1^{st} Symposium on genesis and evolution of organics in space organized by IIST., Indian Institute of Space Science and Technology (IIST) , Trivandrum, 18-20 January, 2024.

Dipen Sahu

234. "Genesis of organics in ISM to Solar type of protostars and planetary bodies, an astronomers perspective", An invited talk presented at the First Symposium on Genesis and Evolution of Organics in Space organized by IIST, Trivandrum, Indian Institute of Space Science and Technology (IIST), Trivandrum, 18-20 January, 2024.
235. "From prestellar core to planetary bodies - Astrochemical origin and habitability", International Conference on Planets, Exoplanets, and Habitability, organized by PRL and IPSA, Physical Research Laboratory, Ahmedabad, 5- 9 February, 2024.
236. "Digging into fundamental processes of star formations inside prestellar cores and its connection with astrochemistry", Authors: Dipen Sahu[1], Sheng-Yuan Liu[2], Naomi Hirano[2], Doug Johnstone[3], Neal J Evans II[4], Ken Tatematsu[5], and the ALMASOP team, presented [Oral] by Dipen Sahu in National Space Science Symposium (NSSS-2024)., Goa University, 26 Feb - 01 Mar 2024.

Lectures at Universities / Institutions

Astronomy and Astrophysics

Santosh Vadawale

1. “Roaming on the Moon”, TIFR ASSET Colloquium at TIFR, Mumbai, October 09, 2023

Shashikiran Ganesh

2. “Polarimetry of solar system bodies using PRL facilities”, Colloquium at Institute of Astrophysics - FORTH, Heraklion, Greece, September 20, 2023

Vishal Joshi

3. “Knowing the cosmo-giant: A Black Hole in the center of our galaxy”, lecture delivered at the department of Physics, Saurashtra University, Rajkot, March 04, 2024
4. “A flavour of research in Astrophysics”, lecture given at Christ College, Rajkot, January 10, 2024
5. “Fascinating world of exoplanets”, lecture given at R. R. Mehta college of Science, Palanpur, July 22, 2023

Ashirbad Nayak

6. “The Evolution of the Mount Abu 1.2m Telescope”, Lecture given at the Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital, November 21, 2023

Ruchi Pandey

7. “Shock-induced dust formation in novae: A phenomenological study”, Seminar at Bloomberg Center for Physics and Astronomy, Johns Hopkins University, USA, October 23, 2023

Namita Uppal

8. “The structure of the Milky Way galaxy at different scales”, Seminar at Lagrange Observatoire de la Côte d’Azur, Nice, France, October 03, 2023.
9. “Probing the Galactic disk structures using red clump stars and interstellar dust”, Seminar at Institute of Astrophysics, University of Crete, Greece, November 08, 2023

Solar Physics

Brajesh Kumar

10. “Solar Structure and Dynamics”, Short Course on Solar Physics by CSSTEAP, 22 - 26 May, 2023
11. “Introduction to our Sun” and ”Solar Internal Structure, Dynamics, and Helioseismology”, USO-PRL Winter School, USO Udaipur, 04 - 08 December, 2023

Raja Bayanna

12. “Image formation & Adaptive Optics along with two tutorials (practicals)”, USO-PRL Winter School, 04 - 08 December, 2023
13. “Instrumentation for Imaging Spectroscopy of the Sun”, Online Short Course on Solar Physics, conducted by Physical Research Laboratory (PRL), Ahmedabad under the auspices of CSSTEAP, affiliated to the United Nations, 22 - 26 May, 2023

Girjesh Gupta

14. “Introduction to Solar Corona”, Short Course on Solar Physics by CSSTEAP, 22 - 26 May, 2023
15. “The Sun and Space Weather”, Lectures in UN/CSSTEAP PG Course, September, 2023
16. “Introduction to Coronal Heating”, USO-PRL Winter School, USO Udaipur, 04 - 08 December, 2023

Bhuwan Joshi

17. “The Dynamic Sun and Space Weather”, General Physics Lecture Series, HNBGU Golden Jubilee Year Celebrations, HNB Garhwal (Central) University (HNBGU), (online), 21st February, 2023
18. “Importance of solar observations from multiple vantage points and topics for L1-L4 collaborations”, Korea Astronomy and Space Science Institute (KASI), Daejeon, South Korea, 30th October, 2023
19. “Onset and evolution of solar flares: A multi-wavelength perspective”, Leibniz Institute for Astrophysics Potsdam (AIP), Potsdam, Germany, 2nd February, 2024

Rohan Louis

20. “Astronomical & Heliographic Co-ordinate Systems”, USO-PRL Winter School, USO Udaipur, 04th December, 2023
21. “Sunspots: A High Resolution Perspective”, USO-PRL Winter School, USO Udaipur, 05th December, 2023

Kushagra Upadhyay

22. "Ground based solar radio observation at USO-PRL: Present capabilities & future prospects", Guest talk at Giant Metrewave Radio Telescope (GMRT), 20th July, 2023
23. "Solar radio physics", Talk and practical session conducted in an online short course on solar physics under the CSSTEAP programme, 22 - 26 May , 2023
24. "Solar radio bursts & e-CALLISTO measurements", Online practical session conducted in 13th Post Graduate Course in Space and Atmospheric Sciences (SAS), 21st November, 2023

Ramit Bhattacharyya

25. "Coronal magnetic field-I", Online short course on solar physics under the CSSTEAP programme, 22 - 26 May, 2023
26. "Coronal magnetic field -II", Online short course on solar physics under the CSSTEAP programme, 22 - 26 May, 2023
27. "Numerical simulation of magnetic reconnection", USO-PRL Winter School, USO Udaipur, 05th December, 2023

Nandita Srivastava

28. "Coronal mass ejections and their space weather effects", the Institute of Engineering Physics of Samarkand State University, Uzbekistan, 31st October, 2023
29. "Recent developments in solar and heliophysics research", the Institute of Engineering Physics of Samarkand State University, 31st October, 2023

Planetary Sciences

Anil Bhardwaj

30. "Indian Planetary and Space Missions", Institute Lecture of IIT Roorkee, May 8, 2023
31. "Institute Foundation Day Lecture", Institute of Seismological Research (ISR), Govt of Gujarat-DST, Raisan, Gandhinagar, Gujarat, May 20, 2023
32. "Planetary Missions of India", Ahmedabad University, October 18, 2023
33. "Institute Public Lecture", IIT Kanpur, March 27, 2024
34. "Disruptive Science for Innovative and Sustainable Development - Science for Society, Culture & Heritage", Ahmedabad Management Association (AMA), Ahmedabad, June 26, 2023
35. "The Solar System", Online Course on Space Technology & Applications for School Teachers (TGT & PGT), IIRS, Dehradun, June 20, 2023

Dwijesh ray

36. "Space Rocks: The poor Mans probe", Sagar Science Forum, Shivamogga, Karnataka, October 29, 2023

Jayesh P. Pabari

37. "How to write a research proposal?", GTU, Ahmedabad, January 24, 2024
38. "How to write a research proposal?", Silver Oak University, Ahmedabad, January 23, 2024

Kinsuk Acharyya

39. "Astrochemistry: Making of Simple through Complex molecules in the astrophysical conditions", IIT Patna, February 29, 2023
40. "Astrochemistry: Understanding our Chemical Universe", IIT Kanpur, March 4, 2023

M. Shanmugam

41. "Insights of Chandrayaan-3 and Aditya-L1 missions", Indus University, Ahmedabad, October 12, 2023

Rishitosh K. Sinha

42. "India's Ambitious Chandrayaan-3 Mission to the Moon", Lovely Professional University, Phagwara, September 15, 2023

Varun Sheel

43. "Planetary Science & Exploration", National Institute of Technical Teachers' Training & Research (NITTTR), Chandigarh, November 9, 2023
44. "Climate of Mars and Venus", Department of Physics, Punjab University, Chandigarh, November 8, 2023
45. "Physical Processes in the Martian Atmosphere", Department of Physics & Astrophysics, Delhi University, March 2, 2024

Space and Atmospheric Sciences

Duggirala Pallamraju

46. "Introduction to Space Weather", AAYAM23 - An Astronomical Fest, Bhilai Institute of Technology, Durg, Chhattisgarh, 9 October 2023

Lokesh Kumar Sahu

47. "Measurements of reactive trace gases in urban regions of India: Emissions and atmospheric processes", Meteorological Research Institute (MRI), Tsukuba, Japan, 8 November 2023
48. "Sources of volatile organic compounds in urban regions of India: Implications to secondary pollutants", Research Institute for Humanity and Nature (RIHN), Kyoto, Japan, 2 November 2023
49. "Preparation of a Review Article", 30^{th} Short Term Course : Research Paper Writing & Publication for Teachers and Research Scholars, Sardar Patel University, Vallabh Vidyanaga, Gujarat, 12 August 2023

T A Rajesh

50. "In-situ measurements and remote sensing of atmospheric parameters, and Optical Techniques", 13^{th} Post Graduate Course on Space and Atmospheric Sciences (SAS) conducted by UN Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), 13 Lectures (1 hr each) (SAS13 [102], [103]), September - October 2023

Harish Gadhavi

51. "Earths Atmosphere Weather and Climate", 13^{th} Post Graduate Course on Space and Atmospheric Sciences (SAS) conducted by UN Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), (SAS13 [103]), June 2023

R P Singh

52. "Structure and Variability of Earths Ionosphere and Airglow", 13^{th} Post Graduate Course on Space and Atmospheric Sciences (SAS) conducted by UN Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), 16 lectures (1 hr each) (SAS13 [102]), September to November 2023
53. "Two Practicals", 13^{th} Post Graduate Course on Space and Atmospheric Sciences (SAS) conducted by UN Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), 8 November 2023
54. "Airglow techniques to study upper atmosphere", Mentored the project in ISRO Structured Training Programme (STP), PRL Ahmedabad, 25-29 September 2023
55. "Evolution and Advancements in Sensors and Optical Systems for Indian Space Programme", Structured Training Programme (STP) hosted by LEOS at ISRO guest House, Bangalore, 8 - 12 January 2024

Amitava Guharay

56. "Structure and dynamics of Earths atmosphere", 13^{th} Post Graduate Course on Space and Atmospheric Sciences (SAS) conducted by UN Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), 12 lectures (1 hr each) (SAS13), 11-15th October 2023
57. "Two Practicals", 13^{th} Post Graduate Course on Space and Atmospheric Sciences (SAS) conducted by UN Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), 16 November 2023
58. "Atmospheric structure and dynamics", Workshop on Space weather science and opportunities organized by PRL, 17-18 October 2023

Geosciences

M. G. Yadava

59. "'Paleoclimate at SAC during training on Satellite Meteorology and Global Climate (SATMET)-13", Three course lectures given on Paleoclimate at SAC during training on Satellite Meteorology and Global Climate (SATMET)-13, 29-31 Jan 2024

Anil D. Shukla

60. "Lunar and Martian Analogues from Indian Geological ecords", Delivered online lecture entitled Lunar and Martian Analogues from Indian Geological ecords to M. Tech. students from Indian Institute of Remote Sensing (IIRS) Dehradun, May 5, 2023

Arvind Singh

61. "living component of the coupled ocean-atmosphere system at international SOLAS summer school", Two lectures on the living component of the coupled ocean-atmosphere system at international SOLAS summer school in Cape Verde, June 4-26, 2023
62. "International Earth Science Olympiad (IESO) students", Six lectures to International Earth Science Olympiad (IESO) students, Aug 19-20, 2023
63. "Sustainable forest management and Coastal zone management to the III semester M.Sc. students at Gujarat University, Ahmedabad", Course lectures (8 lectures) on Sustainable forest management and Coastal zone management to the III semester M.Sc. students at Gujarat University, Ahmedabad, July- Aug, 2023
64. "Climate Modelling", Course lectures (10 lectures) on Climate Modelling to the II semester M.Sc. students at Gujarat University, Ahmedabad, Jan- Mar 2024
65. "Paleoclimate", Course lectures (8 lectures) on Paleoclimate to the I semester M.Sc. students at Gujarat University, Ahmedabad, Nov- Dec 2023
66. "Statistics lectures in the Advanced B.Sc. Physics course at St. Xaviers, Ahmedabad", Statistics lectures in the Advanced B.Sc. Physics course at St. Xaviers, Ahmedabad, May 5, 2023
67. "Climate action, Life below water, Life on the water at UGC-HRDC", Four lectures (6 hrs) on Climate action, Life below water, Life on the water at UGC-HRDC at Pondicherry University by Pondicherry University, Sep 13 - Mar 05, 2023

Yogita Kadlag

68. "Physical properties and average atomic numbers of chondrules using computed tomography", November 2023 Invited virtual talk Physical properties and average atomic numbers of chondrules using computed tomography (Invitation from Prof. Hsien Shang, Academia Sinica Institute of Astronomy and Astrophysics PO Box 23-141, Taipei, Taiwan 10617), Nov 2023

Shubhra Sharma

69. "The emergent Himalayas: Geology, Vulnerability, Disasters", The emergent Himalayas: Geology, Vulnerability, Disasters as a resource person in lecture series and member of workshop on Perception of Risk in Himalayas in Centre for Inter-Asian research, Ahmedabad University, Dec 8, 2023

Theoretical Physics

Srubabati Goswami

70. "From an impossible dream to the unreachable stars", Colloquium delivered at Ashoka University, Shonepath, India, April 26, 2023
71. "The Fable of the Unstable Neutrinos", Talk delivered at Oklahoma State University, Oklahoma, USA, October 17, 2023
72. "From an impossible dream to the unreachable stars", Colloquium delivered at Oklahoma State University, USA, October 17, 2023
73. "The Fable of the Unstable Neutrinos", Talk delivered at Texas A&M, College Station, USA, January 25, 2024
74. "The Fable of the Unstable Neutrinos", talk delivered at University of Washington, St. Louis, USA, February 1, 2024
75. "Neutrino oscillation and decay in matter", Talk delivered at Northwestern University, Evanston, USA, February 16, 2024

Dayanand Mishra

76. "QED effects on inclusive and exclusive B meson decays", Talk delivered at Tata Institute of Fundamental Research, Mumbai, April 21, 2023

Partha Konar

77. "Deep Learning Frontier in Particle Physics", Colloquium delivered at NISER, Bhubaneswar, April 5, 2023
78. "AI and Machine learning", Set of lecture presentations and hands on tutorial sessions on AI and Machine learning (with Dr. Vishal Ngairangbam) for a national preparatory school in online mode, June 19 - 21, 2023

Ketan M. Patel

79. "Quantum Mechanics", Set of eleven lectures given at Advanced BSc summer programme, St. Xavier's College Ahmedabad, May 6 - 23, 2023
80. "Flavour hierarchies from radiative corrections", A lecture given at International Centre for Theoretical Physics, Trieste, Italy, June 13, 2023

Paramita Dutta

81. "Generation and detection of odd-frequency pairings in topological Jossephson junction", Talk delivered at Saha Institute of Nuclear Physics, Kolkata, July 13, 2023

Animesh Chatterjee

82. "BSM Searches at Neutrino experiment", Summer student lecture at CERN, Geneva on online mode, August 24, 2023
83. "Neutrino oscillations and beyond", EP-nu lecture series at CERN, Geneva, September 1 - December 31, 2023

Satyajit Seth

84. "H+jet production at NLP accuracy", Talk delivered at IMSc, Chennai, March 27, 2024
85. "H+jet production at Next-to-leading power accuracy", Talk delivered in LAPTh, Annecy, France, November 15, 2023

Computer Networking and Information Technology (CNIT) Division

Jigar Raval

86. "Cyber Security Concepts", as a part of 3 months Digital Proficiency Programme conducted by Adani Institute of Digital Technology Management (AIDTM), January 2024 to March 2024
87. "Importance of Cyber Security", L. D. College of Engineering as a part inauguration of Cyber Force club, February 20, 2024
88. "Email Forensics Concepts, Tools and Techniques", L J University, Ahmedabad, January 04, 2024
89. "Email Forensics Concepts, Tools and Techniques", Faculty of Science, M. S. University, Vadodara, February 03, 2024
90. "Overview of Cyber Security Threats and Challenges", IIRS, Dehradun as a part of online course on Geo-data sharing and Cyber Security, November 29, 2023
91. "Secure Your Digital World", PRL, October 26, 2023
92. "Strengthening the Human Firewall", Institute of Plasma Research (IPR), Gandhinagar, October 13, 2023
93. "Email Forensics Concepts, Tools and Techniques", As a part of Cyber Security Awareness Month 2023 at Khyati School of Computer Application, Ahmedabad, October 30, 2023
94. "Email Forensics Concepts, Tools and Techniques", As a part of Cyber Security Awareness Month 2023 at Government of MCA College, Ahmedabad, October 19, 2023
95. "Email Forensics Concepts, Tools and Techniques", As a part of Cyber Security Awareness Month 2023, delivered an expert series at School of Engineering and Applied Science, Ahmedabad University, September 06, 2023

Girish Padia

96. "Deep dive into most common web attack", Khyati School of Computer Application Ahmedabad on February 02, 2024, February 02, 2024
97. "Deep dive into most common web attack", Pandit Deendayal Energy University on March 19, 2024, March 19, 2024

Tejas Sarvaiya

98. "2023 Solution Challenge", Served as an Expert Jury Member for the Charotar University of Science & Technology at KDPIT, CSPIT, CHARUSAT, September 29, 2023

Atomic, Molecular and Optical Physics

R. P. Singh

99. "Beyond Qubit", SRM University-AP, Amravati, September 20, 2023
100. "Experiments in Free Space Quantum Key Distribution", The Indian Institute Of Technology (IIT) Mandi, October 18, 2023
101. "Experiments in Free Space Quantum Key Distribution", University of Kerala, November 9, 2023
102. "Satellite-Based Quantum Communication: Challenges", Centre for Quantum Technologies (CQT) at IIT Delhi, November 7, 2023

B. K. Sahoo

103. "Modern Atomic Physics Research: Testing quantum many-body methods and beyond", A seminar at the Applied Physics Department, Faculty of Technology and Engineering, The MS University of Baroda, February 24, 2024

B.Sivaraman

104. "Laboratory Astrochemistry", GITAM University, 25 April, 2023
105. "Laboratory astrochemistry - Part 1 and 2", Vellore Institute of Technology (VIT), Vellore, 8-9 May, 2023
106. "The Physical and Chemical Nature of Astrochemical Dust", Vellore Institute of Technology (VIT), Vellore, 11 May, 2023
107. "Micro Crystals Are Made In A Millisecond", Alagappa University, 21-23 June, 2023.
108. "Feynman Lecture Series - Chapter 1", CHARUSAT University, 1 July, 2023
109. "Chemistry in Space Science", An online lecture delivered at ISRO - Space Science and Technology Awareness Training (START), 26 July, 2023
110. "Laboratory Astrochemistry - The importance of VUV spectroscopy", A lecture delivered at RRCAT, Indore, 31 July, 2023
111. "Laboratory Astrochemistry", A lecture delivered at St Josephs University., 21 September, 2023
112. "Laboratory Astrobiology", A lecture delivered at Providence College for Women, Coonoor., 23 November, 2023.
113. "Astrobiology - Making the first cell", A lecture delivered at Government College, Ooty., 24 November, 2023

Naveen Chauhan

114. "Post Violet-Infrared Stimulated Luminescence (pVIRSL) Dating: A new luminescence protocol for dating Potassium Feldspars", An oral talk delivered at XXI INQUA (International Union for Quaternary Research) Congress 2023, held in Rome, Italy., 14 20 July, 2023
115. "A Post Violet-Infrared Single Aliquot Regenerative (pVIR-SAR) Protocol", An invited talk delivered at the University of Lausanne, Switzerland., 10 July, 2023
116. "Understanding Luminescence and its Applications", An invited talk delivered at CHARUSAT University, 21 June, 2023
117. "Basics of Luminescence Chronology", An invited talk delivered at Kutch University, 5 August, 2023

Science Outreach Talks by PRL Scientists

Astronomy and Astrophysics

Santosh Vadawale

1. “Chandrayaan-3: En avismaraniya anubhav”, Talk in Gujarati given at the Lokbharti University, Sanosara, on 13-01-2024

Aveek Sarkar

2. “ADIA-L1 The first Indian space mission to observe the sun Palladian House”, A popular talk given at Annual Education Camp, Barwaha, MP, on 23-12-2023

Vishal Joshi

3. “Success stories of Indian space research program”, A lecture delivered at Dept. of Physics, Saurashtra University, Rajkot, on 29-09-2023
4. “A visit to the astrophysical Zoo”, A lecture delivered at Govt. Science College, Gariadhar, on 26-02-2024
5. “Way of growth: learn, fail, relearn”, A lecture delivered in Orientation Program, Ganpat University, Mehsana, on 17-07-2023
6. “A journey leading to the Vaidya Metric”, A lecture delivered at Vigyan Gurjari, Shri Labhubhai Trivedi Institute Of Engineering & Technology, Rajkot, on 18-06-2023
7. “Why do stars twinkle?”, A lecture given at Pandit Deendayal Energy University (PDEU), Gandhinagar, on 26-05-2023
8. “Contribution of amateur astronomers in astrophysics”, A talk given in Astronomy and Astrophysics for amateur astronomers, National Institute of Technology - Calicut, Kozhikode, on 05-05-2023

Solar Physics

Ananya Rawat

9. “The Sun: Source of Light and Life”, USO-PRL seminar hall as outreach activity, on 06-11-2023
10. “The Sun: Our Nearest Star”, USO-PRL seminar hall as part of outreach activity, on 18-01-2024

Satyam Agarwal

11. “Understanding the Enigmatic Sun”, USO-PRL seminar hall as part of outreach activity, on 13-10-2023

Sandeep Kumar

12. “Origin of Stellar Energy”, Krea University, Sricity, on 11-01-2024

Bhuwan Joshi

13. “Solar Physics and Aditya-L1”, seminar for M.Sc. students on career in Solar Physics at Dept of Physics, Mohanlal Sukhadia University (MLSU), Udaipur, on 07-04-2023
14. “Space Exploration”, at Mikado International School, Udaipur, on 12-09-2023
15. “The Sun and Space Weather”, during World Space Week Celebrations at USO-PRL, Udaipur, on 10-10-2023

Ramit Bhattacharyya

16. “Solar Physics and Aditya-L1”, at Gaza High School, Hugly, West Bengal, on 16-10-2023

Planetary Sciences

Anil Bhardwaj

17. “Inaugural Lecture, Science and Spirituality: Two-sides of a Coin”, Science and Spirituality Quest Five-day Workshop, Indrashil University, Kadi., on 01-03-2023
18. “Indian Space Program”, Vijnana Bharati talk at Physics Department, Gujarat University, on 08-08-2023
19. “World Space Week Celebration Online Talk on Planetary Missions of India”, Nehru Science Centre, Mumbai, on 05-10-2023
20. “Indian Planetary Science Program, Resonance Science, Outreach Program”, Kashmir University, Srinagar, on 10-10-2023
21. “Online Interaction with Students”, Gaza High School, Hooghly, on 16-10-2023
22. “NIAS-DST training Lecture in Program on Science and Technology”, Global Developments and Perspective, NIAS, Bangalore, on 28-11-2023
23. “Chandrayaan-3”, Challenges & Success, Ramakrishna Mission School, Gwalior, on 19-12-2023
24. “Lunar Exploration Program of India, Public Lecture @ ASI 2024”, Jawaharlal Nehru Planetarium, Bangalore, on 31-01-2024

25. "Environment over Mars & Payloads for a Mars Solar UAV", in Challenges in Design of Solar UAV for exploring Mars, 7th National Aircraft Conceptual Design Competition (NACDeC-VII), organized by Aeronautical Society of India., on 13-02-2024
26. "Indian Planetary Mission", Students Session at NSSS-2024, Goa Univ., Goa, on 27-02-2024

Jayesh P. Pabari

27. "Dust in solar system", Navyug Vidyalaya, Porbandar, on 21-01-2024

M. Shanmugam

28. "Exploring Chandrayaan-3: Advancements in Lunar Exploration", Association of Indian Physicists (AIP), NISER, Bhubaneshwar, on 15-10-2023

Megha Bhatt

29. "Lunar Science: A Popular Perspective", Science city event on Chandrayaan-3 landing, on 23-08-2023

Neeraj Srivastava

30. "Science of the Moon", DD Girnar in the backdrop of the historic Chandrayaan3 landing on the Moon. https://www.youtube.com/watch?v=fBxfIFFWpx0, on 20-07-2023
31. "Lunar Science: A Popular Perspective", Science city event on Chandrayaan-3 landing, on 23-08-2023

S. A. Haider

32. "An overview of science and explorations of Indian missions", 6th International Conference on Recent Trends in Materials and Devices ICRTMD-2023 held at Amity University, Noida, on 20-12-2023

S. Vijayan

33. "Chandrayaan-3 Mission: Exploring the Moon", kurukshetra 2024, College of Engineering, Guindy, Anna University, on 02-03-2024
34. "Chandrayaan-3 Mission: Landing on the Moon", Celestia 2024, Institute of Remote Sensing, Anna University, on 12-03-2024

Geosciences

Yogita kadlag

35. "Celestial bodies", Delivered a talk on Celestial bodies in universe at Space Application Center, Ahmedabad, on 16-05-2023

Theoretical Physics

Partha Konar

36. "In an era of Artificial Intelligence", Talk delivered on National Science Day program for school children at PRL, Ahmedabad, on 06-03-2024

Navinder Singh

37. "Choosing a career in Physics", Talk delivered on National Science Day at PRL, on 06-03-2024

Atomic, Molecular and Optical Physics

R. P. Singh

38. "Quantum Communication", An outreach talk given at SRM University-AP, Amravati, on 21-09-2023

B. Sivaraman

39. "Biography of molecules beyond Earth", A webinar delivered at Creactive - Bangalore, on 08-07-2023

Area Seminar by visitors

Mr. Mathieu Van der Donckt

1. “Overview of the TRAPPIST program and recent highlights”, University of Liege, Belgium, on 03-04-2023

Prof. Eswar Reddy

2. “Unravelling the Origin Mystery of anomalously large lithium in red giants”, Indian Institute of Astrophysics, Bengaluru, on 20-07-2023

Dr. Kiritkumar Makwana

3. “Cosmic Ray Transport in Magnetohydrodynamic Turbulence”, IIT, Hyderabad, on 17-01-2024

Dr. M. S. Nanda Kumar

4. “Hub-filament systems as progenitors of star cluster formation”, Instituto de Astrofísica e Ciências do Espaço, Universidade do Porto, CAUP, Porto, Portugal, on 29-02-2024

Dr. Mayukh Pahari

5. “Understanding the innermost geometry of accreting Seyfert galaxies using X-ray reverberation techniques”, IIT, Hyderabad, on 11-03-2024

Dr. Arghajit Jana

6. “Changing-State AGNs: Challenging our Understanding of AGNs”, Universidad Diego Portales, Santiago, Chile, on 13-03-2024

Dr. Narasimha Murty

7. “Silicon Carbide/Diamond Electronics for extreme environments”, IIT Tirupati, on 28-07-2023

Prof. Martin Paetzold

8. “Reprocessing of Pioneer Venus Orbiter Radio Occultation data from 1978 - 1982”, RIU at Cologne University, Department Planetary Research, Cologne, Germany, on 23-02-2024

Dr. Michael Pezzopane

9. “Importance of Swarm satellite data to improve our understanding of the magnetosphere-thermosphere-ionosphere system”, Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy, on 19-06-2023

Dr. Sandeep Pattnaik

10. “Prediction of Extreme Events in Climate Change Scenarios over the Indian region”, Indian Institute of Technology, Bhubaneswar, on 21-08-2023

Dr. Suman Chakraborty

11. “Understanding the dynamics of the Earths radiation belts: a giant space donut filled with highly energetic charged particles”, Northumbria University, Newcastle upon Tyne, UK, on 28-08-2023

Mr. Soumen Datta

12. “Investigation on lightning and thunderstorm systems using NavIC/GPS satellite signal and ground data”, Indian Institute of Technology, Indore, on 11-09-2023

Dr. Ruchita Shah

13. “Investigation of cloud properties due to warming atmosphere over India and adjoining oceanic regions”, Pandit Deendayal Energy University, Gandhinagar, on 18-09-2023

Prof. Herman Russchenberg

14. “Advances in atmospheric cloud remote sensing and modelling with the Ruisdael Observatory in the Netherlands”, Delft University of Technology, The Netherlands, on 09-10-2023

Dr. Mahesh Kumar Sha

15. “Remote sensing of greenhouse gases from ground-based and space-based instrumentations”, Royal Belgian Institute for Space Aeronomy (BIRA-IASB), Brussels, Belgium, on 11-12-2023

Dr. Isamu Morino

16. "Greenhouse gas observations by the GOSAT series and ground-based FTS operated by NIES", National Institute for Environmental Studies (NIES), Japan, on 11-12-2023

Mr. Purushottam Kumar

17. "Enabling Routine Chemical Composition and Volatility Distribution Measurements of Aerosols", Virginia Tech, USA, on 22-01-2024

Prof. Mark Baskaran

18. "Disequilibria of ^{210}PO:^{210}PB:^{226}RA studies tracers and chronometers for environmental changes during Anthropocene", Wayne State University, USA, on 21-07-2023

Dr. Kaustubh Thirumalai

19. "Extreme Indian monsoon states lead to oceanic productivity collapses", Department of Geosciences, University of Arizona, USA, on 08-02-2024

Dr. Manudeo Singh

20. "Floodplains hydrogeomorphic assessment using optical and radar remote sensing methods", Humboldt Postdoctoral Fellow, University of Potsdam, on 06-11-2023

Dr. Nilanjana Sorcar

21. "Making and collapse of mountain belts: insights from petrography, thermodynamic modelling and diffusion kinetics", National Center for Earth Science Studies, Thiruvananthapuram, on 09-01-2024

Dr. Upasana Banerji

22. "Insights into the abrupt climatic events (ace) of Holocene: a paleoclimate conundrum", Ministry of Earth Science, New Delhi, on 30-01-2024

Dr. Manibrata Sen

23. "Supernovae as laboratories for fundamental neutrino physics", Max-Planck-Institut für Kernphysik, Heidelberg, Germany, on 18-04-2023

Ms. Debika Debnath

24. "Phase Diagram of the 2D Extended Holstein-Hubbard Model: An Analytical Mean-Field Study", University of Hyderabad, Hyderabad, on 25-04-2023

Ms. Sanchari Bhattacharyya

25. "Lights on a Left-Right symmetric model in the LHC era", University of Calcutta, Kolkata, on 04-05-2023

Prof. T R Govindarajan

26. "Ultra ligt dark matter - A novel proposal", The Institute of Mathematical Sciences, Chennai, on 08-06-2023

Dr. Arnab Chaudhuri

27. "Dark Matter Production from Two Evaporating PBH Distributions", IIT Gandhinagar, on 13-06-2023

Mr. Prabhat Solanki

28. "Triggering long-lived particles (LLPs) at the first stage of the trigger system at HL-LHC", Indian Institute of Science, Bangalore, on 14-06-2023

Dr. Jalaja Pandya

29. "Heusler compounds for Spintronics and Thermoelectric Applications", Pandit Deendayal Energy University, Gandhinagar, on 15-06-2023

Dr. Soumya Jana

30. "Black hole shadows and no-hair theorem", Sitananda College, West Bengal, on 03-07-2023
31. "Gravitational radiation from compact binaries: Effective field theory approach", Sitananda College, West Bengal, on 04-07-2023

Prof. Biswarup Mukhopadhyay

32. "Some minimum bias suggestions on WIMP dark matter", IISER, Kolkata, on 10-07-2023

Prof. Tirthankar Roy Choudhury

33. "Cosmology Using Neutral Hydrogen", National Centre for Radio Astrophysics (NCRA), TIFR, Pune, on 13-07-2023

Dr. Abhishek Mohapatra

34. "Heavy Quarkonium Hybrids in Effective Field Theory", Technical University of Munich, Germany, on 18-07-2023
35. "Effective theories for heavy quark system", Technical University of Munich, Germany, on 28-08-2023
36. "Exotic XYZ mesons", Technical University of Munich, Germany, on 29-08-2023

Dr. Udit Khanna

37. "Edge Reconstruction and Bulk Ferromagnetism in quantum Hall phases", Bar-Illan University, Israel, on 27-07-2023
38. "Introduction to Quantum Hall Effect", Bar-Illan University, Israel, on 23-08-2023
39. "Quantum Hall Phase Diagram of Bilayer Graphene", Bar-Illan University, Israel, on 24-08-2023

Dr. Deobrat Singh

40. "Revolutionizing Green Hydrogen Production through Catalytic Pathway Prediction using Hybrid Eigenvector-Following DFT Method on Layered Materials", Uppsala University, Sweden, on 28-07-2023

Mr. Shivam Gola

41. "Pseudo scalar dark matter in a generic $U(1)_X$ model", The Institute of Mathematical Sciences, Chennai, on 22-08-2023

Dr. Shishir Kumar Pandey

42. "A Route To Access The Quantum Spin Liquid state In Spin-orbit Coupling Assisted Mott Insulators", Artificial Intelligence for Science Institute, Beijing, China, on 31-08-2023

Mr. Ravi Shanker

43. "$U_A(1)$ restoration and the properties of eigenvalues of 2+1 flavor QCD Dirac operator", The Institute of Mathematical Sciences, Chennai, on 05-09-2023

Mr. Monal Kashav

44. "Effective way of Model Building with Modular Symmetries", Central University of Himachal Pradesh, on 26-09-2023

Mr. Kuntal Bhattacharyya

45. "Correlated transport in quantum dot-based hybrid systems", School of Physics, University of Hyderabad, on 09-10-2023

Prof. Rahul Sinha

46. "Use of Bose symmetry to test symmetry violations", The Institute for Mathematical Sciences, Chennai and University of Hawaii, on 06-11-2023

Dr. C S Yadav

47. "Spin ice phase in some topological materials", IIT Mandi, on 28-12-2023

Dr. Anirban Das

48. "Exploring the Dark Sector: New Regimes, New Ideas", Dept. of Physics & Astronomy, Seoul National University, South Korea, on 15-01-2024

Dr. Anish Ghoshal

49. "Hearing the Universe Hum with Gravitational Waves and Primordial Black Holes at Pulsar Timing Array: astrophysical, cosmological and particle physics interpretations", University of Warsaw, Poland, on 18-03-2024

Dr. Divya Sachdeva

50. "Probing the Hidden Universe: Direct and Indirect Searches of Dark Matter", LPENS, Sorbonne University, France, on 19-03-2024

Technical/ Scientific talk given in Hindi [Oral & Poster Presentations]

Oral Presentations

1. Anil Bhardwaj, PRL: 'Exploration of Solar System", IISU, Trivandrum, 02-06-2023 and Gujarat State-Level Hindi Technical Seminar, organized by PRL, Ahmedabad, 24-11-2023.
2. Ashutosh Gupta, SAC: "Blockchain Technology-Introduction and Perspective for Sustainable Space Applications", PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.
3. B.N. Sharma, SAC: "Climate Change: Causes, Effects and Solutions", PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.
4. Bhaskar Dubey, Nikunj P. Darji, Debjyoti Dhar, SAC: "In-flight geometric calibration and applications of Cartosat-1 satellite", PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.
5. Chandrashekhar, Arvind Patel, SAC: "Structural analysis of EPC of QUANTESS", PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.
6. Dinesh Aggarwal, SAC: "Challenges and future for ISRO's sustainable projects", PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.
7. Hitendra Mishra, PRL: "Computing and technological innovation", PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.
8. Jagdamba Prasad Singh, Akhilesh Sharma, PRL: "Role of space science in sustainable agriculture and food security amid the disasters of climate change", PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.
9. Jayesh P. Pabari, PRL: "Lightning strike and weather change", PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.
10. Jitendra Kumar, PRL: "High Resolution Remote Sensing from Geospatial Platform: Applications, Challenges and Solutions", PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.
11. Kushagra Upadhyay, PRL: "Climate change: From changes in Earth's temperature to extreme events", PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.
12. Manisha Gupta, SAC: "Usefulness of space science and technology in sustainable development", PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.
13. Narendra Ojha, PRL: "Modeling urban ozone dynamics using machine learning", PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.
14. Prashant Gupta, M. K Praneeth Sagyanmatula, J.B. Rami, PRL: "Techniques for analyzing acceleration signals in sine vibration testing", PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.
15. Ramakant R. Mahajan, PRL: "Impact of extraterrestrial matter on Earth's climate", PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.
16. Rohit Singh, PRL: "Contribution of space technology and ISRO in sustainable development", PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.
17. Siddharth Sarkar, Ajeyata Rathi, Mohammad Atif Khan, Sanjeev Kumar, PRL: "Transport and transformation of particulate black carbon along the river continuum", PRL Hindi Technical Seminar, Ahmedabad, 16.08.2023.
18. Sonam Jitarwal, PRL: 'Analysis of different design configurations for the Venus Lightning Instrument (LIVE)", PRL Hindi Technical Seminar, Ahmedabad, 16.08.2023.
19. Tejas N. Saravaiya, PRL: "Virtualization a cost-effective and environment-friendly key enabler of digital transformation", PRL Hindi Technical Seminar, Ahmedabad, 16.08.2023.
20. V.S. Jagadish, SAC: "Structural analysis of micro-vibration effects on GA-set payloads", PRL Hindi Technical Seminar, Ahmedabad, 16.08.2023.
21. Yogesh Ghotekar, Dr. Suresh Kumar, Justin George, SAC: "Measurement of soil respiration in different land use systems of the Lesser Himalayan region", PRL Hindi Technical Seminar, Ahmedabad, 16.08.2023.
22. Yogita Kadlag, PRL: "Microcomputing section drawing techniques for space and geological applications", PRL Hindi Technical Seminar, Ahmedabad, 16.08.2023.
23. Shashi Prabhakar, PRL: "Coincidence counting - quantum perspective", Scientific talk given in Hindi at AMOPH Division seminar, PRL, 15.12.2023.

Poster Presentations

1. Amarnath, RamakrishnaThakkar, Shweta kirkire, SAC: “Conservation of Natural Resources From Scarcity to Sustainability“, PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.

2. Ashwani Kumar, Vishal sakarwadiya, Parul Singh, SAC: “Design and development of visual sensor technology “, PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.

3. Ankita Patel, Vaibhav Dikshit, Mudit Kumar Shrivastava, PRL: “Adaptive Optics (AO) Project“, PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.

4. Rohit Meena, Jay Dave, Atinder Pal Singh, SAC: “Impact of lockdown on aerosol concentrations in Ahmedabad“, PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.

5. Deepak Kumar Rai, Abul Kasim, Jitendra Kumar, Ravi Bhushan, Sanjeev Kumar, Arvind Singh, PRL: “Glacial-interglacial oxygen variability in the Arabian Sea“, PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.

6. Shreya Mehta, Ranar Kikar, Helena haus, Narendra ojha, Arvind Singh, PRL: “Contribution of dust deposition and phosphate flux to Trichodesmium abundance.“, PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.

7. Himanshu Shukla, Sharad Shukla, PRL: “Reduction of acid consumption by modifying the composition of acid solutions used in surface treatment to reduce harmful effects on climate.“, PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.

8. Sunil Sharma, SAC: “Climate change“, PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.

9. Ashish Jain, Kapil Sharma, Sudheer Agrawal, SAC: “Near real time ionospheric monitoring portal using GAGAN“, PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.

10. Neha Goud, SAC: “Quantum technology from scientific concept to sustainable communication“, PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.

11. Vivek Sharma, SAC: “Roadmap for the future: Towards sustainable management and sustainable development“, PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.

12. Krishna Makani, SAC: “Sustainable development and renewable planning“, PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.

13. Avnish Jain, Neeta V. Seth, SAC: “Space Debris Control: Why and How?“, PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.

14. Harish Seth, SAC: “Future roadmap From sustainable management to sustainable development “, PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.

15. Lokendra Chauhan, Samyak Jain, SAC: “Sustainable Materials and Manufacturing: Pioneering a Green Future“, PRL Hindi Technical Seminar, Ahmedabad,16.08.2023.

16. Jaymeen Patel, H.H. Parmar, Raja Dave, Satish Prasad, SAC: “Possibilities of using artificial intelligence in testing payload systems and sub-systems“, PRL Hindi Technical Seminar, Ahmedabad, 16.08.2023.

17. Alka, NISP team, PRL: “Near-infrared Imager, Spectrometer and Polarimeter (NISP)“, PRL Hindi Technical Seminar, Ahmedabad,16.08.2024.

18. Virendra R Padhya, PRL: “Atmospheric water vapor dynamics at Guru Shikhar, Mount Abu (Rajasthan), the highest point of the Aravalli Range“, PRL Hindi Technical Seminar, Ahmedabad,16.08.2025.

19. Himanshu Saxena, Deepika Sahoo, Sipai Najirahmed, Deepak Kumar Rai, Mohammad Atif Khan, Niharika Sharma, Sanjeev Kumar, PRL: “Contribution of carbon fixation towards carbon sink in the ocean twilight zone “, PRL Hindi Technical Seminar, Ahmedabad, 16.08.2026.

20. Puneet Verma, Satish, R.V., Kumari, K.M., Lakhani, A., SAC: “Basic polycyclic aromatic hydrocarbons and their nitro-derivatives and their variations with NOx“, PRL Hindi Technical Seminar, Ahmedabad, 16.08.2027.

21. Subhadyuti Bose, Neeraj Srivastava, PRL: “Manned missions to the Moon should we explore polar or equatorial regions¿‘, PRL Hindi Technical Seminar, Ahmedabad, 16.08.2028.

22. Arvind Patel, SAC: “Structural analysis of X-band altimeter Gaganyaan“, PRL Hindi Technical Seminar, Ahmedabad, 16.08.2029.

23. Deepak Kumar, PRL: “Failure Analysis of Lens Assembly“, PRL Hindi Technical Seminar, Ahmedabad, 16.08.2030.

24. Rohit Kumar, Anil Sukheja, SAC: “Use of Internet of Things technology in monitoring and control of environmental parameters and applications in space science.“, PRL Hindi Technical Seminar, Ahmedabad, 16.08.2031.

25. Deepchandra, SAC: “Discussion on ISRO’s sustainable development programs in Mann Ki Baat: An analysis“, PRL Hindi Technical Seminar, Ahmedabad, 16.08.2032.

26. Mudita Tater, Anil Dutt Shukla, Amrita Dutt, PRL: “Anorthosites: an approach to understanding the geology of the Moon“, PRL Hindi Technical Seminar, Ahmedabad, 16.08.2023.

27. Kapil Kumar Bhardwaj, PRL: "Development of fruit (apple) classification system", PRL Hindi Technical Seminar, Ahmedabad, 16.08.2023.

28. Ambili Narayanan, Shivansh Verma, Anil D. Shukla, PRL: "High Value Metal Isotope Analysis of Geological Samples Using MC-ICP-MS", PRL Hindi Technical Seminar, Ahmedabad, 16.08.2023.

Student Training

Astronomy and Astrophysics

1. Rahul Thakur, National Institute of Technology, Warangal, “Aspects of the Optical Design of an Ultra-Violet Spectrometer”, from May 2023 to July 2023, [Supervisor: Mudit K. Srivastava].
2. Saket Pinapati, Birla Institute of Technology and Science, Pilani, “Understanding Evolution of Star Clusters with UVIT”, from May 2023 to July 2023, [Supervisor: Manash Samal].
3. Kishan Malaviya, St Xaviers college, Ahmedabad, “Image simulation of astronomical Sources”, from January 2022 to May 2023, [Supervisor: Shashikiran Ganesh].
4. Priyanka Khandelwal, Gujarat University. Ahmedabad, “Test and Evaluation of Detectors in IR & Visible Region For Astronomical Polarimetric Applications”, from January 2023 to June 2023, [Supervisor: Shashikiran Ganesh].
5. Astha Gupta, Birla Vishvakarma Mahavidyalaya, “Astronomical Large Data Reduction: GUI for EMPOL Data Analysis”, from January 2023 to May 2023, [Supervisor: Shashikiran Ganesh].
6. Akshat Trivedi, Birla Vishvakarma Mahavidyalaya, “Astronomical Large Data Reduction”, from January 2023 to May 2023, [Supervisor: Shashikiran Ganesh].
7. Ritavash Debnath, Indian Institute of Science Education and Research, Pune, “Modeling of Spectral Energy Distribution of Galaxies”, from May 2023 to July 2023, [Supervisor: Veeresh Singh].
8. Isha Mahuvakar, Gujarat University Ahmedabad, “Active Galactic Nuclei with Large Scale Radio Structures”, from February 2023 to March 2024, [Supervisor: Veeresh Singh].
9. Arunansh Sharma, Madhav Institute of Technology and Science, Gwalior, “The Fruit Grading Machine Design”, from January 2023 to May 2023, [Supervisor: Kapil Kumar Bharadwaj].
10. Hetvee Talati, Birla Vishvakarma Mahavidyalaya, Vallabh Vidyanagar, Gujrat, “The Fruit Grading Machine Design”, from January 2023 to May 2023, [Supervisor: Kapil Kumar Bharadwaj].
11. Braj Mohan Vyas, Madhav Institute of Technology and Science, Gwalior, “Clean Extraction from Flowers using Supercritical CO2”, from January 2023 to May 2023, [Supervisor: Kapil Kumar Bharadwaj].
12. Bhashkar Shastry, Madhav Institute of Technology and Science, Gwalior, “Clean Extraction from Flowers using Supercritical CO2”, from January 2023 to May 2023, [Supervisor: Kapil Kumar Bharadwaj].
13. Kriyanshi Thakkar, SVKM’s Mithibai College, Mumbai, “Integration of observatory components with Remote Telescope System”, from Nov 2023 to April 2024, [Supervisor: Shashikiran Ganesh].
14. Harshita Singh, IEHE, Bhopal, “Optical test bench setup for characterization of astronomical instruments”, from December 2023 to July 2024, [Supervisor: Shashikiran Ganesh].
15. Sriket Srivastav, NIT, Kurukshetra, “Design simulations of flexure lens mounts for cryogenic applications”, from January 2024 to May 2024, [Supervisor: Shashikiran Ganesh].
16. Dharmik Patel, Parul University, Vadodara, “Development of a Python based housekeeping software for astronomical instrumentation”, from Dec 2023 to April 2024, [Supervisor: Deekshya R.S.].
17. Hirapara Niyati Jayeshbhai, SVNIT, Surat, “Development of FPGA based electronics for laboratory characterisation”, from Jan 2024 to May 2024, [Supervisor: Deekshya R.S.].
18. Sauptik Das, University of Calcutta. Kolkata, “Characterization of Multi-layer Coatings for Hard X-Ray Optics”, from May 2023 to July 2023, [Supervisor: Mithun N. P. S.].

Solar Physics

19. Mr. Sunil Yadav, IISER Berhampur, “Automated detection of small-scale transients in the solar atmosphere”, from May 2023 to July 2023, [Supervisor: Girjesh Gupta].
20. Ms. Jisna Jojo, St. Xavier’s College, Mumbai, “A study of Fourier and wavelet power spectrum along solar coronal loops”, from Nov 2023 to March 2024, [Supervisor: Girjesh Gupta].
21. Ms. Aishita Prakash, Ms. Tanvi Bhatnagar, and Ms. Fatima Patwala, College of Technology and Engineering (CTAE), Udaipur, “Introduction to Image Formation in Astronomy”, from July 2023 to July 2023, [Supervisor: Rohan Eugene Louis].
22. Mr. Vaibhav Jain, College of Technology and Engineering (CTAE), Udaipur, “Radio Antennas for Astronomical Sciences & Its front-end electronics”, from 1 June 2024 to 31 July 2024, [Supervisor: Kushagra Upadhyay].
23. Mr. Hariom and Mr. Yogesh Tailor, College of Technology and Engineering (CTAE), Udaipur, “Development of Mechanical System for the Sun Tracking of 2m Dish Antenna”, from 1 June 2024 to 31 July 2024, [Supervisor: Kushagra Upadhyay].
24. Mr. Shanmugha Balan, BITS, Pilani, “Development of Forecasting Tool for Space Weather Impact of CMEs”, from August 2023 to December 2023, [Supervisor: Nandita Srivastava].
25. Ashutosh Dash, Central University of Haryana, “Understanding The Earth-Impacting CMEs”, from May 2023 to June 2023, [Supervisor: Nandita Srivastava].

Planetary Sciences

26. Eesha Kabra, Savitribai Phule Pune University, Pune, "Contribution from Transient Lunar Volcanism to Lunar Polar Volatile Deposits", from June 2023 to July 2023, [Supervisor: Anil Bhardwaj].
27. Ajay Kumar Yadav, IISER Tirupati, "One-Year Masters Thesis", from July 2023 to March 2024, [Supervisor: Anil Bhardwaj].
28. Anjana Shaju, IISER, Mohali, "Refractory Inclusions in CM and CV chondrite", from May 2023 to July 2023, [Supervisor: Dipak Kumar Panda].
29. Dipansu Dipayan Behera, NISER, Bhubaneswar, "Mineralogical study in Carboneceous Chondrite", from May 2023 to July 2023, [Supervisor: Dipak Kumar Panda].
30. Sushanta Ghosh, IIT(ISM), Dhanbad, "Surface and Subsurface Geology of Mars revealed by Rover", from May 2023 to July 2023, [Supervisor: Dwijesh Ray].
31. Ananya Rani panda, IIEST, Shibpur, "Mineralogical and Spectral characterization of meteoritic fall L/LL in India", from May 2023 to July 2023, [Supervisor: Dwijesh Ray].
32. Shivani Singh, B. V. M. Engg. College, Vallabhvidyanagar, "Prototype of plane parallel impact ionization dust detector", from December 2022 to May 2023, [Supervisor: J. P. Pabari].
33. Janki Shah, L.D. College of Engineering, Ahmedabad, "Requirements for lightning prediction through AI/ML", from January 2023 to May 2023, [Supervisor: J. P. Pabari].
34. Anushka Singh, NIT, Patna, "Measurable Schumann Resonance using Mars Climate Database", from January 2023 to June 2023, [Supervisor: J. P. Pabari].
35. Khushi Sharma, NISER, Bhubaneshwar, "Study of Circumsolar dust ring in the orbit of Venus using PSP Observations", from May 2023 to July 2023, [Supervisor: J. P. Pabari].
36. Shivam Saxena, J. S. University, Shikohabad, "Possibility of dust devils around Gale crater on Mars", from May 2023 to July 2023, [Supervisor: J. P. Pabari].
37. Khushi Yadav, NIT, Kurukshetra, "Study of impact plasma due to dust impact", from January 2024 to May 2024, [Supervisor: J. P. Pabari].
38. Kriti Shrivastava, Institute for Excellence in Higher Education, Bhopal, "Characteristics of electric and magnetic fields in whistler waves", from December 2023 to May 2024, [Supervisor: J. P. Pabari].
39. Pankaj Kumar, Chandigarh University, Mohali, "Study of dust ablation in planetary atmosphere and associated chemistry", from January 2024 to June 2024, [Supervisor: J. P. Pabari].
40. Tejaswi Kondhiya, CSSTEAP, "Study of streamer during lightning", from March 2024 to September 2024, [Supervisor: J. P. Pabari].
41. Yogita Mulye, L.D. College of Engineering, Ahmedabad, "Development of Meteorological Suite for future lander missions", from January 2023 to June 2023, [Supervisor: Chandan Kumar].
42. Aman Ratho, Silver Oak University, "Laboratory Analysis of Volatiles in Planetary Sciences", from September 2023 to March 2024, [Supervisor: Kinsuk Acharyya].
43. Neha, Banasthali Vidyapith, "Investiagtion of Organic Matter in Aubrites", from January 2023 to June 2023, [Supervisor: Kuljeet Kaur Marhas].
44. Mohmmad Jiruwala, Birla Vishwakarma Mahavidyalay, "Lab Monitoring System for Nano-SIMS Lab", from Feb 2023 to May 2023, [Supervisor: Kuljeet Kaur Marhas].
45. Jainil Shah, Birla Vishwakarma Mahavidyalay, "Backend Lab Monitoring System for Nano-SIMs Lab", from Feb 2023 to May 2023, [Supervisor: Kuljeet Kaur Marhas].
46. Himanshu Bansal, Indian Institute of Science Education & Research, Tirupati, "Processing of telescopic lunar data and application of Hapke model.", from June 2023 to July 2023, [Supervisor: Megha Bhatt].
47. Prajul Adhikari, National Institute of Technology, Silchar, "Application of Hapke and Monte Carlo Models to reflectance spectra.", from June 2023 to July 2023, [Supervisor: Megha Bhatt].
48. Denesh K., NIT Hamirpur, "Reflectance Spectroscopy of Mars Analogues", from May 2023 to July 2023, [Supervisor: Neeraj Srivastav].
49. Dhwanil Patel, M.G. Science Institute, Ahmedabad, "Reflectance Spectroscopy of Mars Analogues", from May 2023 to July 2023, [Supervisor: Neeraj Srivastava].
50. Madan Fozia, Gujarat University, Ahmedabad, "Reflectance Spectroscopy of Lunar analogue as a function of viewing geometry", from December 2023 to March 2024, [Supervisor: Neeraj Srivastava].
51. Tejas Dave, Gujarat University, Ahmedabad, "Reflectance Spectroscopy of Lunar analogue as a function of viewing geometry", from December 2023 to March 2024, [Supervisor: Neeraj Srivastava].
52. Dhwanil Patel, M.G. Science Institute, Ahmedabad, "Reflectance Spectroscopy of Martian analogue as a function of viewing geometry", from December 2023 to March 2024, [Supervisor: Neeraj Srivastava].
53. Denesh K, NIT, Hamirpur, "Reflectance Spectroscopy of Martian analogue as a function of viewing geometry", from December 2023 to March 2024, [Supervisor: Neeraj Srivastava].
54. Akash Gautam, Panjab University, Chandigarh, "Geological mapping of the landing site of Chandrayaan-3 mission", from January 2024 to May 2024, [Supervisor: Rishitosh K. Sinha].
55. Aditi R, CEG, Anna University, "Geological and mineralogical exploring of Schamberger A crater", from December 2023 to April 2024, [Supervisor: Vijayan S].
56. Adithya K, Cochin University, "Mars analogue terrain exploration", from December 2023 to April 2024, [Supervisor: Vijayan S].
57. Thahira U, Bharathidasan University, "Chryse Planitia, Mars: Potential landing site on Mars", from December 2023 to April 2024, [Supervisor: Vijayan S].
58. Bivas Das, Banaras Hindu University, "Geological and mineralogical exploring of Schomberger A crater", from June 2023 to March 2024, [Supervisor: Vijayan S].
59. Chinmay Shahi, Delhi Technological University, "Belva crater, Mars: Evidence for last stage fluvial activities", from June 2023 to April 2024, [Supervisor: Vijayan S].

60. Jiten Dhaka, Delhi University, India, “Atmospheric Escape and Significant Physical Processes”, from Jan 2023 to May 2023, [Supervisor: Sanjay K. Mishra].
61. Ritika Raj, IISER Tirupati, India, “Thermal Escape of the Planetary Atmosphere”, from May 2023 to June 2023, [Supervisor: Sanjay K. Mishra].
62. Kiiran Jadhav, Vellore Institute of Technology, Vellore, “Modelling Crater formed by Hypervelocity Impact”, from December 2023 to May 2024, [Supervisor: Srirag N. Nambiar].
63. Manan Shukla, L.D. College of Engineering, Ahmedabad, “Study on Optimization of Impact Plasma Detection Area for Dust Sensor”, from May 2023 to July 2023, [Supervisor: Srirag N. Nambiar].
64. Tirtha Jyoti Kalita, CSSTEAP, “Radio Occultation for Venus Atmosphere”, from January 2023 to September 2023, [Supervisor: Varun Sheel].

Space and Atmospheric Sciences

65. Komal, PRL, JRF, “Study of electrodynamics of Ionosphere by analysing ion drifts”, from January 2023 to April 2023, [Supervisor: Duggirala Pallamraju].
66. Komal, PRL, JRF, “Study of electrodynamics of Ionosphere by analysing Jicamarca incoherent scatter radar data”, from August 2023 to December 2023, [Supervisor: Duggirala Pallamraju].
67. Sandip Bhattacharyya, PRL, JRF, “Estimation of Earths Magnetic Field through Digisonde Measurements over Ahmedabad”, from August 2023 to December 2023, [Supervisor: Duggirala Pallamraju].
68. Arjun K R, Indian Institute of Science, Engineering and Research (IISER), Mohali, “Investigations of space weather effects in near-Earth environment using airglow emissions”, from May 2023 to July 2023, [Supervisor: Duggirala Pallamraju].
69. Misha Joshi, Dharmsinh Desai University Nadiad, Gujarat, “Simulations for the design of Drift Meter Payload”, from December 2023 to March 2024, [Supervisor: Pankaj K Kushwaha].
70. Krisha Parikh, Charotar University of Science and Technology (CHARUSAT), Changa, Gujarat, “Simulations for the design of Drift Meter Payload”, from January 2024 to March 2024, [Supervisor: Pankaj K Kushwaha].
71. Ajay Kumar Yadav, Indian Institute of Science Education and Research (IISER), Tirupati, “Investigations on the fluctuations in the solar wind alpha-proton ratio using wavelet techniques”, from July 2023 to April 2024, [Supervisor: Dibyendu Chakrabarty].
72. Viswavijay Sharma, PRL, JRF, “Study of non-radial solar wind”, from July 2023 to December 2023, [Supervisor: Dibyendu Chakrabarty].
73. Shivam Parashar, PRL, JRF, “Ionospheric irregularities, radio signals and navigations”, from July 2023 to December 2023, [Supervisor: Dibyendu Chakrabarty].
74. Aakash Gupta, PRL, JRF, “Variation of theTemperature Ratio of Alpha and Proton($T\alpha/Tp$) During Minimum and Maximum of the Solar cycle 24”, from August 2023 to December 2023, [Supervisor: Dibyendu Chakrabarty].
75. Akshaat Singh, Institute of Technology, Nirma University, Ahmedabad, “Application of Computational Fluid Dynamics (CFD) in Atmospheric Sciences”, from January 2023 to May 2023, [Supervisor: Som Kumar Sharma].
76. Akshay Kumar Gupta, Institute of Technology, Nirma University, Ahmedabad, “Application of Computational Fluid Dynamics (CFD) in Atmospheric Sciences”, from January 2023 to May 2023, [Supervisor: Som Kumar Sharma].
77. Pragati, Chandigarh University, Punjab, “Web Development for Visualizing Meteorological Data”, from January 2023 to May 2023, [Supervisor: Som Kumar Sharma].
78. Shashwat Singh, Punjab Technical University, Jalandhar, Punjab, “Web Development for Visualizing Meteorological Data”, from January 2023 to May 2023, [Supervisor: Som Kumar Sharma].
79. I.K. Gujral, Punjab Technical University, Jalandhar, Punjab, “Web Development for Visualizing Meteorological Data”, from January 2023 to May 2023, [Supervisor: Som Kumar Sharma].
80. Mayank Bhardwaj, Garhwal University, Uttarakhand, “Atmospheric Contrasts: Exploring the Climate Differences between the Indo-Gangetic Plain, Delhi and Semi-Arid Region, Ahmedabad”, from May 2023 to July 2023, [Supervisor: Som Kumar Sharma].
81. Hemvati Nandan Bahuguna, Garhwal University, Uttarakhand, “Atmospheric Contrasts: Exploring the Climate Differences between the Indo-Gangetic Plain, Delhi and Semi-Arid Region, Ahmedabad”, from May 2023 to July 2023, [Supervisor: Som Kumar Sharma].
82. Ayush Kumar Sinha, Central University of Rajasthan, “Study of Cloud Base Height over Semi-Arid Region Ahmedabad and Indo-Gangetic Plain New Delhi”, from May 2023 to July 2023, [Supervisor: Som Kumar Sharma].
83. Ishaan Kanade, Vellore Institute of Technology, Chennai, “Study of Atmospheric Clouds and Water Vapor over Western Indian Region using Ground-based and Satellite Observations”, from December 2023 to December 2023, [Supervisor: Som Kumar Sharma].
84. Pranjal Mishra, Vellore Institute of Technology, Chennai, “Study of Atmospheric Clouds and Water Vapor over Western Indian Region using Ground-based and Satellite Observations”, from December 2023 to December 2023, [Supervisor: Som Kumar Sharma].
85. Sachin Kori, Indian Institute of Science Education and Research (IISER), Tirupati, “An algorithm to get LIDAR ratio using twilight time LIDAR data”, from July 2023 to April 2024, [Supervisor: Harish Gadhavi].
86. Rajan K. Dave, L. D. College of Engineering, Ahmedabad, “Evaluation of mechanical design of sun-photometer as balloon payload”, from May 2023 to July 2023, [Supervisor: Harish Gadhavi].
87. Debanandan Mahapatra, Central University of Rajasthan, “Understanding FLEXPART: A Lagrangian particle dispersion model”, from May 2023 to July 2023, [Supervisor: Harish Gadhavi].
88. Shreya Sasi, Indian Institutes of Science Education and Research (IISER) Kolkata (INSPRE SHE Scholar), “Comparison of Ionospheric Total Electron Content between GPS observations and NeQuick2 model”, from May 2023 to July 2023, [Supervisor: K Venkatesh].

89. Chitra Raghavan, PRL, Sci/Engg 'SD', "Space weather effects on GNSS 3D positioning", from August 2023 to September 2023, [Supervisor: K Venkatesh].
90. Aakash Gupta, PRL, JRF, "Latitudinal and Longitudinal response of the ionospheric Total Electron Content (TEC) during intense solar flares", from January 2023 to May 2023, [Supervisor: K Venkatesh].
91. Sandip Bhattacharyya, PRL, JRF, "Unusual variations of Ionospheric Total Electron Content (TEC) over Ahmedabad", from January 2023 to May 2023, [Supervisor: K Venkatesh].
92. Akash Ganguly, PRL, Sci/Engg 'SD', "Elucidating factors governing DST index during Geomagnetic Storms: Insights from a novel Statistical Framework", from July 2023 to December 2023, [Supervisor: K Venkatesh].
93. Amit Chaturvedi, PRL, JRF, "Ionospheric and plasmaspheric electron content variations over Ahmedabad using IRI-PLAS model", from July 2023 to December 2023, [Supervisor: K Venkatesh].
94. Akash Ganguly, PRL, Sci/Engg 'SD', "Forecasting DST index during Geomagnetic Storms: A novel Machine Learning Approach", from July 2023 to December 2023, [Supervisor: K Venkatesh].
95. Pardeep, Central University of Rajasthan, Ajmer, "Study of Mesosphere Lower Thermosphere Dynamics", from May 2023 to July 2023, [Supervisor: R P Singh].
96. Ankita Chaurasia, PRL, JRF, "Study of sudden stratospheric warming", from January 2024 to March 2024, [Supervisor: R P Singh].
97. Aliya M. Kureshi, St. Xaviers College, Ahmedabad, "Satellite-informed machine learning models for estimating particulate matter in north-western India: A fusion of data analytics and remote sensing", from September 2023 to March 2024, [Supervisor: Narendra Ojha].
98. Ruwaydahzehra K. Bukhari, St. Xaviers College, Ahmedabad, "Assessing long-term changes in atmospheric trace gases and aerosol optical depth across India: A comprehensive analysis", from September 2023 to March 2024, [Supervisor: Narendra Ojha].

Geosciences

99. Mr. Hasnain Raza, Aligarh Muslim University, INSA SRFP, "Isotopic Measurement of Water Samples from Laser Analyser"", from July 2023 to Aug 2023, [Supervisor: M.G. Yadava].
100. Aditi Thaker, Ahmedabad University, Ahmedabad, "Chemical Characterization of Ambient Aerosols", from May 2023 to July 2023, [Supervisor: Neeraj Rastogi].
101. Ms. Chaitra S., Jyoti Nivas College, Bangalore, "Dissolved Rare Earth Elements in seawater: measurement and depth profile", from March 2024 to April 2024, [Supervisor: A. K. Sudheer].
102. Pranita Paradkar, INSPIRE fellow MS University Baroda, "Alkalinity analogs", from May 2023 to July 2023, [Supervisor: Arvind Singh].
103. Aharna Sarkar, IISER Pune, "Measuring soil CO_2 efflux using non-steady state closed chamber technique and studying the effect of soil moisture on soil CO_2 efflux", from July 2023 to Aug 2023, [Supervisor: Amzad H. Laskar].
104. Pritha Bagchi, Presidency University Kolakata, "Groundwater Dating from Ganga Plain", from Jul 2023 to Aug 2023, [Supervisor: Amzad H. Laskar].
105. Srijita Das, Jadavpur University, Kolkata, "Radiocarbon Dating of Soil Organic Carbon from Tropical Soils", from Jul 2023 to Aug 2023, [Supervisor: Amzad H. Laskar].
106. Asish Behera, IISER Pune, "Understanding the variability in stable Carbon and Nitrogen isotopes in Neoproterozoic shale: Implications towards past biological productivity", from June 2023 to July 2023, [Supervisor: Vineet Goswami].
107. Arjun Singh, BHU, Varanasi, "Geochemical analyses of black shales from Bhander Group, upper Vindhyan: Understanding the Neoproterozoic ocean redox", from May 2023 to June 2023, [Supervisor: Vineet Goswami].
108. Tanushri Malviya, BHU, Varanasi, "Geochemical and isotopic analyses of marine sediments from the Northeastern Indian Ocean: Implication towards understanding the past oceanic circulation", from May 2023 to June 2023, [Supervisor: Vineet Goswami].
109. Vaishvi Tyagi, University of Delhi, Delhi, "Understanding the chronology of marine sediments using radiocarbon", from May 2023 to June 2023, [Supervisor: Vineet Goswami].
110. Ronak Kumar Maurya, St. Xaviers College Ahmedabad, "Chemical Separation and isotope analysis of chromium in geological reference materials", from Jan 2023 to May 2023, [Supervisor: Yogita Kadlag].

Theoretical Physics

111. Mr. Spandan Pandya, Ashoka University, Sonepat, Haryana, "Neutrino oscillations and Decay", from 1 Jun, 2023 to 15 Jul, 2023, [Supervisor: Srubabati Goswami].
112. Mr. Somnath Mandal, National Institute of Technology, Silchar, "Neutrino Oscillation", from 18 May, 2023 to 16 Jul, 2023, [Supervisor: Srubabati Goswami].
113. Mr. Mitesh Behera, University of Hyderabad, Hyderabad, "Flavour Symmetry and Neutrino Mass", from 15 Mar, 2023 to 21 Apr, 2023, [Supervisor: Srubabati Goswami].
114. Ms. Sanchari Bhattacharya, University of Calcutta, Kolkata, "Left-Right symmetric model", from 15 Apr, 2023 to 14 May, 2023, [Supervisor: Srubabati Goswami].
115. Mr. Shivam Gola, The Institute of Mathematical Sciences, Chennai, "Dark Matter", from 14 Aug, 2023 to 13 Sep, 2023, [Supervisor: Srubabati Goswami].
116. Mr. Rutvik Ashish Mahajan, Indian Institute of Science Education and Research, Kolkata, "Introduction to General Relativity and Cosmology", from 10 May, 2023 to 08 Jul, 2023, [Supervisor: Namit Mahajan].
117. Ms. Jhanvi Shailesh Shah, Charotar Uni of Science and Technology, Anand, "Study of Point Transformer on Point Cloud Data and its Implementation", from 2 Jan, 2023 to 1 May, 2023, [Supervisor: Partha Konar].

118. Mr. Dheirya Rajendrabhai Bhatt, Indus University, Ahmedabad, “Hyperbolic Function Implementation in Particle Physics through Machine Learning”, from 11 Jan, 2023 to 25 Apr. 2023, [Supervisor: Partha Konar].
119. Mr. Priyansh Jitendrakumar Parmar, Indus University, Ahmedabad, “Autoencoder based Anomaly Detection in Particle Physics”, from 11 Jan, 2023 to 25 Apr. 2023, [Supervisor: Partha Konar].
120. Mr. Rajveer Bijendrasinh Rathod, Birla V M, Vallabh Vidyanagar, Anand, “Exploring Hypergraph Message Passing in Particle Physics”, from 2 Jan, 2023 to 28 Apr, 2023, [Supervisor: Partha Konar].
121. Mr. Shubham Shakya, Indian Institute of Space Science and Technology, Thiruvananthapuram, “Production of Dark Matter”, from 1 Jun, 2023 to 30 Jun, 2023, [Supervisor: Partha Konar].
122. Ms. Sonali Panda, AMOPH, PRL, Ahmedabad, “Machine Learning: Exploration of Monte Carlo Tree Search Algorithm in the Context of Tic Tac Toe”, from 1 Aug, 2023 to 21 Dec, 2023, [Supervisor: Partha Konar].
123. Mr. Shantanu Shakya, Indian Institute of Space Science and Technology, Thiruvananthapuram, “Experimental demonstration of the Barkhausen effect and design of a prototype kit for colleges and universities”, from 4 Jun, 2023 to 30 Jul, 2023, [Supervisor: Navinder Singh].
124. Ms Anjali Patel, St. Xavier College, Ahmedabad, “Piezoelectric sensor based altimeter kit: concept and design”, from 24 Jan, 2023 to 30 Jul, 2023, [Supervisor: Navinder Singh].
125. Ms. Anchal Patel, St. Xavier College, Ahmedabad, “Piezoelectric sensor based altimeter kit: concept and design”, from 24 Jan, 2023 to 30 Jul, 2023, [Supervisor: Navinder Singh].
126. Mr. Aniket Sengupta, Indian Institute of Science Education and Research, Pune, “Introduction to topology in condensed matterIntroduction to Superconductivity”, from 15 May, 2023 to 10 Jul, 2023, [Supervisor: Paramita Dutta].
127. Ms. Gauri Ingole, Indian Institute of Science Education and Research, Bhopal, “Introduction to topology in condensed matters”, from 15 May, 2023 to 10 Jul, 2023, [Supervisor: Paramita Dutta].
128. Ms. Dhruvi Patel, Gujarat University, Ahmedabad, “Properties of Quasicrystals”, from 8 Jun, 2023 to 7 Aug, 2023, [Supervisor: Paramita Dutta].
129. Mr. Paras Thacker, St. Xavier’s College, Ahmedabad, “Detection of Dark Matter using timing information”, from 15 Mar, 2023 to 25 May, 2023, [Supervisor: Animesh Chatterjee].
130. Mr. Paras Thacker, St. Xavier’s College, Ahmedabad, “Effect of neutrino decay at the long-baseline neutrino experiments”, from 1 Sep, 2023 to 31 Mar, 2024, [Supervisor: Animesh Chatterjee].
131. Mr. Sharoz Schezwen, Nanyang Techical University, Singapore, “Probing for Heavy Neutral Lepton at DUNE and ICARUS (mode: Online)”, from 1 Jul, 2023 to 31 May, 2024, [Supervisor: Animesh Chatterjee].
132. Mr. Sreejit Das, Indian Institute of Science Education and Research, Kolkata, “Feynman Integrals via Mellin-Barnes approach”, from 15 May, 2023 to 10 Jul, 2023, [Supervisor: Satyajit Seth].
133. Mr. Ramanan Aiyer, Indian Institute of Technology, Gandhinagar, “Exploring ML for analytic simplifications”, from 15 May, 2023 to 10 Jul, 2023, [Supervisor: Satyajit Seth].

Atomic, Molecular and Optical Physics

134. Mr. Shivam Sawarn, Hindu College, University of Delhi, “Quantum network simulation”, from May 15, 2023 to July 10, 2023, [Supervisor: R. P. Singh].
135. Mr. Parvatesh Parvatikar, NIT Warangal, “SPDC-based DV-QKD”, from May 15, 2023 to July 10, 2023, [Supervisor: R. P. Singh].
136. Amandeep Singh, Earth & Environmental Studies, NIT Durgapur, “Europa: A Geological Exploration, Exploring the previous studies and providing new frontiers for proof of active surface and liquid in the subsurface”, from May 15, 2023 to July 15, 2023, [Supervisor: B. Sivaraman].
137. Souvik Panda, Dept of Geological Sciences, Jadavpur, Kolkata, “An Overview of the Study of Martian Minerals”, from June 15, 2023 to July 15, 2023, [Supervisor: B. Sivaraman].
138. Aswin R, IISER Bhopal, “Mid-IR Characterization Of Interstellar Icy Mantles: A Study On Reversible Phase Change”, from May, 2023 to April, 2023, [Supervisor: B. Sivaraman].
139. Vartika Vishnoi, Banaras Hindu University, “STRONG FIELD IONIZATION OF ATOMS AND MOLECULES”, from May 15, 2023 to July 3, 2023, [Supervisor: Rajesh Kumar Kushawaha].
140. Ms. Belani Triya Mukeshbhai, Department of Physics and Electronics, St. Xaviers College (Autonomous), Ahmedabad, “Femtosecond laser filamentation”, from March 9, 2023 to May 23, 2023, [Supervisor: Rajesh Kumar Kushawaha].
141. Mr. Parth Khanduri, CHARUSAT University, “M.Sc. dissertation on The development of surface exposure dating using luminescence.”, from August, 2022 to April, 2023, [Supervisor: Naveen Chauhan].
142. Mr. Kaushik Vala, MSU Baroda, “the basics of luminescence dating for sediments for archaeological samples”, from November 15,2023 to November 30, 2023, [Supervisor: Naveen Chauhan].
143. Mr. Partha Pratim Kar, IIT Gandhinagar, “the basics of luminescence dating for sediments”, from September 25, 2023 to October 9,2023, [Supervisor: Naveen Chauhan].
144. Mr. Partha Pratim Kar, IIT Gandhinagar, “Measurement and dating techniques for archaeological pottery samples”, from November 01, 2023 to November 15, 2023, [Supervisor: Naveen Chauhan].
145. Mr. Ajaykrishna KK, CUSAT, Kerala, “Signal enhancement in nanoparticle enhanced laser-induced breakdown spectroscopy”, from May 15, 2023 to July 10, 2023, [Supervisor: Prashant Kumar].
146. Ms. Hridya P, ST. Josephs College, Devagiri, “Error analysis in the synthetically generated spectrum method for estimation of elemental composition”, from May 15, 2023 to July 10, 2023, [Supervisor: Prashant Kumar].
147. Mr. Akhilesh Dubey, Kirori Mal College, University of Delhi, “Quantum Ghost Imaging”, from May 15, 2023 to July 10, 2023, [Supervisor: Shashi Prabhakar].

Division Visitor Details

Astronomy and Astrophysics

1. Mr. Mathieu Van der Donckt, University of Liege, Belgium, “for collaborative work”, from 27-03-2023 to 09-04-2023,[Seminar : “Overview of the TRAPPIST program and recent highlights”].
2. Prof. Eswar Reddy, Indian Institute of Astrophysics, Bengaluru, “for collaborative discussion”, from 20-07-2023 to 21-07-2023,[Seminar : “Unravelling the Origin Mystery of anomalously large lithium in red giants”].
3. Dr. Kiritkumar Makwana, IIT, Hyderabad, “for collaborative discussion”, from 12-01-2024 to 17-01-2024,[Seminar : “Cosmic Ray Transport in Magnetohydrodynamic Turbulence”].
4. Dr. M. S. Nanda Kumar,, Instituto de Astrofísica e Ciências do Espaço, Universidade do Porto, CAUP, Porto, Portugal, “Collaborative discussion”, from 28-02-2024 to 01-03-2024,[Seminar : “Hub-filament systems as progenitors of star cluster formation”].
5. Mr. Said Hmiddouch, University of Lige, Belgium, “for collaborative work”, from 22-02-2024 to 03-03-2024.
6. Dr. Mayukh Pahari, IIT, Hyderabad, “for collaborative discussion”, from 09-03-2024 to 12-03-2024,[Seminar : “Understanding the innermost geometry of accreting Seyfert galaxies using X-ray reverberation techniques”].
7. Dr. Arghajit Jana, Universidad Diego Portales, Santiago, Chile, “for collaborative discussion”, from 12-03-2024 to 14-03-2024,[Seminar : “Changing-State AGNs: Challenging our Understanding of AGNs”].

Solar Physics

8. Dr. Frederic Schuller, Leibniz-Institut fr Astrophysik Potsdam (AIP), Potsdam, Germany, “Academic visit under Indo-German DST-DAAD personnel exchange program under the project entitled “Exploration of solar flare X-ray emission magnetic reconnection, heating and particle acceleration””, from 03-12-2023 to 12-12-2023,[Seminar : “Multi-instrument studies of solar flares and energetic particles”].
9. Mr. Malte Broese, Leibniz-Institut fr Astrophysik Potsdam (AIP), Potsdam, Germany, “Academic visit under Indo-German DST-DAAD personnel exchange program under the project entitled “Exploration of solar flare X-ray emission magnetic reconnection, heating and particle acceleration””, from 03-12-2023 to 16-12-2023.
10. Prof. Helen Mason, University of Cambridge, UK, “Visit to Udaipur Solar Observatory and interaction with science team”, from 29-11-2023 to 30-11-2023.
11. Dr. Zavkiddin Mirtoshev, Samarkand State University, Samarkand, Uzbekistan, “Exchange visit under Indo-Uzbek project entitled Space Weather Consequences of CMEs”, from 31-07-2023 to 31-08-2023.

Planetary Sciences

12. Prof. Christian Woehler, Technical University Dortmund, Germany, “Moon telescopic observations and scientific discussions”, from 19-02-2024 to 26-02-2024.
13. Prof. Martin Paetzold, RIU at Cologne University, Department Planetary Research, Cologne, Germany, “DST-DAAD Personnel Exchange Program”, from 19-02-2024 to 08-03-2024,[Seminar : “Reprocessing of Pioneer Venus Orbiter Radio Occultation data from 1978 - 1982”].

Space and Atmospheric Sciences

14. Dr. Bhargav Vaidya (and his 2 PhD students Mr. Prateek Mayank and Mr. Sirsha Nandy), Associate Professor from IIT-Indore, “Collaborative Research”, from 18-12-2023 to 23-12-2023.
15. Mr. Purushottam Kumar, PhD Student from Virginia Tech, USA, “Collaborative research and Area Seminar”, from 21-01-2024 to 23-01-2024,[Seminar : “Enabling Routine Chemical Composition and Volatility Distribution Measurements of Aerosols”].

Geosciences

16. Prof. Mark Baskaran, Wayne State University, USA, “To deliver Amrut Vyakhyan”, from 19-07-2023 to 23-07-2023,[Seminar : “Human Impact on Global Climate Change Over the Past Two Centuries: Use of Isotope-Tracing Techniques”].
17. Prof. Mark Baskaran, Wayne State University, USA, “To deliver division seminar”, from 19-07-2023 to 23-07-2023,[Seminar : “Disequilibria of ^{210}PO:^{210}PB:^{226}RA studies tracers and chronometers for environmental changes during Anthropocene”].
18. Dr. Kaustubh Thirumalai, Department of Geosciences, University of Arizona, USA, “Division seminar”, from 07-02-2024 to 08-02-2024,[Seminar : “Extreme Indian monsoon states lead to oceanic productivity collapses”].
19. Dr. Manudeo Singh, Humboldt Postdoctoral Fellow, University of Potsdam, “Division seminar”, from 06-11-2023 to 08-11-2023,[Seminar : “Floodplains hydrogeomorphic assessment using optical and radar remote sensing methods”].
20. Dr. Nilanjana Sorcar, National Center for Earth Science Studies, Thiruvananthapuram, “Division seminar”, from 08-01-2024 to 09-01-2024,[Seminar : “Making and collapse of mountain belts: insights from petrography, thermodynamic modelling and diffusion kinetics”].

21. Dr. Upasana Banerji, Ministry of Earth Science, New Delhi, "Division seminar", from 30-01-2024 to 30-01-2024,[Seminar : "Insights into the abrupt climatic events (ace) of Holocene: a paleoclimate conundrum"].
22. Dr. Atinderpal Singh, Delhi University, "Division seminar", from 05-02-2024 to 13-02-2024.

Theoretical Physics

23. Ms. Sanchari Bhattacharyya, University of Calcutta, Kolkata, "Academic discussions", from 15-04-2023 to 14-05-2023,[Seminar : "Lights on a Left-Right symmetric model in the LHC era"].
24. Mr. Prabhat Solanki, Indian Institute of Science, Bangalore, "Academic discussions", from 06-06-2023 to 20-06-2023,[Seminar : "Triggering long-lived particles (LLPs) at the first stage of the trigger system at HL-LHC"].
25. Prof. T R Govindarajan, The Institute of Mathematical Sciences, Chennai, "Academic discussions", from 08-06-2023 to 08-06-2023,[Seminar : "Ultra ligt dark matter - A novel proposal"].
26. Dr. Arnab Chaudhuri, IIT Gandhinagar, "Academic discussions", from 13-06-2023 to 13-06-2023,[Seminar : "Dark Matter Production from Two Evaporating PBH Distributions"].
27. Dr. Jalaja Pandya, Pandit Deendayal Energy University, "Academic discussions", from 15-06-2023 to 15-06-2023,[Seminar : "Heusler compounds for Spintronics and Thermoelectric Applications"].
28. Dr. Soumya Jana, Sitananda College, West Bengal, "Faculty applicant", from 03-07-2023 to 05-07-2023,[Seminar : "Black hole shadows and no-hair theorem, Gravitational radiation from compact binaries: Effective field theory approach"].
29. Prof. Biswarup Mukhopadhyay, Indian Institute of Science Education and Research (IISER), Kolkata, "Academic discussions", from 10-07-2023 to 14-07-2023,[Seminar : "Some minimum bias suggestions on WIMP dark matter"].
30. Prof. Tirthankar Roy Choudhury, National Centre for Radio Astrophysics (NCRA), TIFR, Pune, "Academic discussions", from 10-07-2023 to 14-07-2023,[Seminar : "Cosmology Using Neutral Hydrogen"].
31. Mr. Shivam Gola, The Institute of Mathematical Sciences, Chennai, "Academic discussions", from 14-08-2023 to 13-09-2023,[Seminar : "Pseudo scalar dark matter in a generic $U(1)_X$ model"].
32. Mr. Kuntal Bhattacharyya, School of Physics, University of Hyderabad, "Academic discussions", from 17-08-2023 to 16-10-2023,[Seminar : "Correlated transport in quantum dot-based hybrid systems"].
33. Dr. Udit Khanna, Bar-Illan University, Israel, "Faculty applicant", from 23-08-2023 to 25-08-2023,[Seminar : "Introduction to Quantum Hall Effect, Quantum Hall Phase Diagram of Bilayer Graphene"].
34. Dr. Abhishek Mohapatra, Technical University of Munich, Germany, "Faculty applicant", from 28-08-2023 to 30-08-2023,[Seminar : "Effective theories for heavy quark system, Exotic XYZ mesons"].
35. Mr. Ravi Shanker, The Institute of Mathematical Sciences, Chennai, "Academic discussions", from 05-09-2023 to 05-09-2023,[Seminar : "$U_A(1)$ restoration and the properties of eigenvalues of 2+1 flavor QCD Dirac operator"].
36. Prof. Rahul Sinha, The Institute for Mathematical Sciences, Chennai and University of Hawaii, "Academic discussions", from 06-11-2023 to 07-11-2023,[Seminar : "Use of Bose symmetry to test symmetry violations"].
37. Dr. C S Yadav, IIT Mandi, "Academic discussions", from 27-12-2023 to 28-12-2023,[Seminar : "Spin ice phase in some topological materials"].
38. Dr. Anish Ghoshal, University of Warsaw, Poland, "Academic discussions", from 18-03-2024 to 20-03-2024,[Seminar : "Hearing the Universe Hum with Gravitational Waves and Primordial Black Holes at Pulsar Timing Array: astrophysical, cosmological and particle physics interpretations"].

Atomic, Molecular and Optical Physics

39. Dr. R Selvakumaran and 7 Masters' students, Amity Centre of Excellence in Astrobiology, Amity University, Mumbai, "Academic interaction and discussion", from 14-03-2024 to 15-03-2024.
40. Prof. AVR Reddy, CEO, Gemmological Institute Of India(GII), "Collaboration and discussions", from 09-01-2024 to 10-01-2024,[Seminar : "Luminescence for diamond research"].
41. Dr. Devender Kumar, Principal Scientist, National Geophysical Research Institute (NGRI), "Discussions", from 05-01-2024 to 06-01-2024,[Seminar : "Luminescence dating applications and issues"].
42. Dr. Rupa Ghosh, DS Kothari fellow, Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow, "Discussions on the new project", from 15-12-2023 to 24-12-2023.
43. Dr. Anil Devara, Assistant Professor, The Maharaja Sayajirao University(MSU), Baroda, "Discussions on the Manuscript", from 15-11-2023 to 30-11-2023.
44. Dr. Antariksha Das, Postdoctoral fellow, Quantum Internet Division (QuTech), Delft University of Technology, Netherlands, "Lab visit, Presenting Division seminar, and interacting with students", from 27-11-2023 to 28-11-2023,[Seminar : "Towards the Quantum Internet: A Long-Lived Multimode Optical Quantum Memory for Quantum Repeaters"].

Astronomy and Astrophysics

Evolution of Elemental Abundances in Hot Active Region Cores from Chandrayaan-2 XSM Observations

The first ionization potential (FIP) bias, whereby elemental abundances for low-FIP (FIP less than 10eV) elements in different coronal structures of the Sun vary from their photospheric values and may also vary with time, has been widely studied. In order to study the temporal variation and understand the physical mechanisms giving rise to the FIP bias, we have investigated the hot cores of three active regions (ARs) using disk-integrated soft X-ray spectroscopic observations with the Solar X-ray Monitor (XSM) on board Chandrayaan-2. Observations for periods when only one AR was present on the solar disk were used to ensure that the AR was the principal contributor to the total X-ray intensity. The average values of temperature and emission measure were ∼3 MK and $3 \times 10^{46}\ cm^{-3}$, respectively. Regardless of the AR's age or activity, the elemental abundances for the low-FIP elements Al, Mg, and Si with respect to the soft X-ray continuum were consistently higher than their photospheric values (Figure 1).

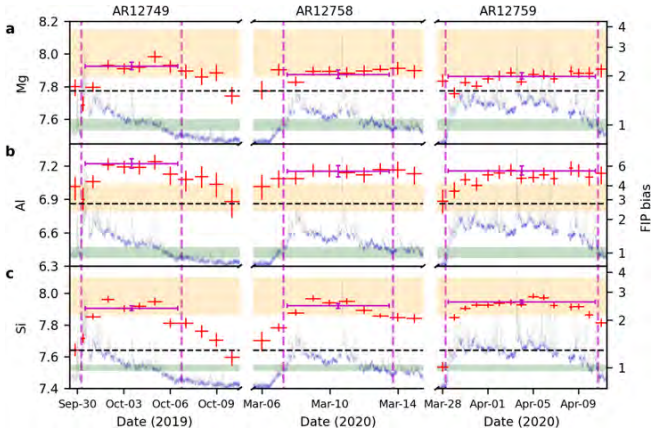

Figure 1: Evolution of Mg, Al, and Si abundances (red error bars) during the evolution of AR 12749, AR 12758, and AR 12759. The magenta bars represent the average abundances when the ARs are very bright, as bounded by the vertical dashed lines. The black horizontal dashed lines represent the average abundance for the quiet Sun in the absence of any AR. The XSM light curves for each AR are shown in gray in the background, and the blue XSM light curves represent the time duration excluding the flaring activities. The range of coronal and photospheric abundances from various authors is shown as orange and green bands. The right y-axis shows the FIP bias values for the respective elements with respect to the average photospheric abundances. This figure is adapted from Mondal et al. (2023).

The average FIP bias for Mg and Si was 2–2.5, whereas the FIP bias for the mid-FIP element, S, was almost unity. However, the FIP bias for the lowest-FIP element, Al, was observed to be a factor of 2 higher than Si, which, if real, suggests a dependence of the FIP bias of low-FIP elements on their FIP value. Another major result from our analysis is that the FIP bias of these elements is established within ∼10 hr of the emergence of the AR and remains almost constant throughout its lifetime.

doi : https://doi.org/10.3847/1538-4357/acdeeb

This work was done in collaboration with G. Del Zanna and H. E. Mason (DAMTP, Cambridge University, UK).

(Biswajit Mondal, N. P. S. Mithun, S. Vadawale, A. Sarkar, P. Janardhan and A. Bhardwaj)

Multiwavelength Observations of a B-class Flare Using XSM, AIA, and XRT

Solar flares are the occasional energy-release events in the solar atmosphere. Understanding the physical mechanisms behind solar flares is an active topic of research in the entire solar physics community. Depending on the X-ray flux of the solar flares, they are categorized into different classes.

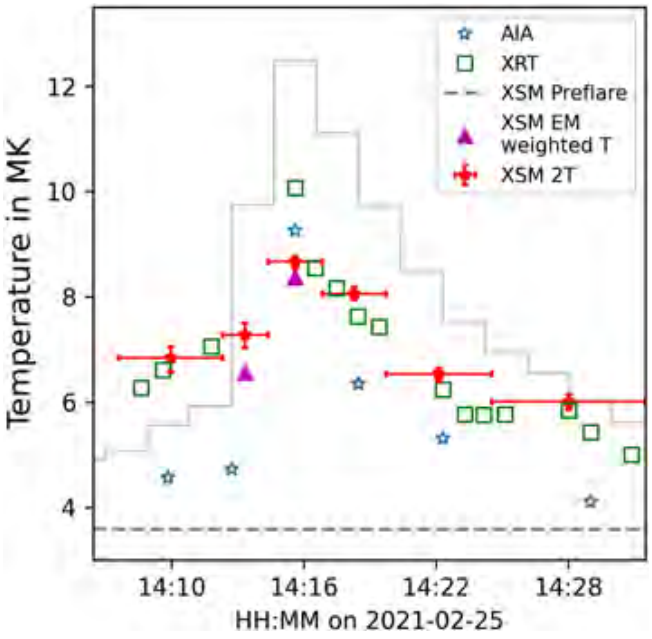

Figure 2: The temporal evolution of temperature using AIA (blue asterisk), XRT (green squares), and XSM (red and pink points). The red points represent the flaring plasma temperature obtained from a two-temperature fit of the XSM spectra, where the gray dashed line represents the temperature of the background AR. The pink triangular points represent the emission-measure-weighted temperature obtained from the cool and hot components of the flaring plasma while considering three-temperature components to the XSM spectra. The gray plot indicates the XSM light curve. This figure is adapted from Rao et al. (2023).

Due to the easy detection of the larger flares, they are extensively studied in the literature compared to the small flares. Here we present multiwavelength studies of a small B-class flare on 1 February 2022, originating from an active region (AR 12804) near the northwest limb of solar disk observed by Chandrayaan-2/Solar X-ray Monitor (XSM), Solar Dynamics Observatory/ Atmospheric Imaging Assembly (AIA), and Hinode/X-Ray Telescope (XRT). This flare lasts for ∼30 minutes and is composed of hot loops reaching temperatures of ∼10 MK. We report excellent agreement (within 20%) for the average effective temperatures obtained at the flare peak from all three instruments (Figure 2), which have different temperature sensitivities. The XRT filter combination of Be-thin and Be-med provides an excellent opportunity to measure the high temperatures in such small flaring events. The elemental abundances during the evolution of the flare are also studied and observed to drop toward photospheric values at the flare peak time, compared to coronal values during the rise and decay phase. This is consistent with previous XSM studies.

doi : https://doi.org/10.3847/1538-4357/acf46a

This work was done in collaboration with Yamini Rao, G. Del Zanna, H. E. Mason (DAMTP, Cambridge University, UK) and K. Reeves (CfA, Harvard University, US).

(Biswajit Mondal, N. P. S. Mithun, S. Vadawale and A. Bhardwaj)

Optical spectroscopy of comets using Hanle Echelle Spectrograph (HESP)

Comets, as remnants of the proto-planetary disk, hold valuable information about the early Solar system. This study focuses on the analysis of four comets, namely 46P, 38P, 41P, and C/2015 V2, using high-resolution spectroscopy to investigate their molecular composition and emission characteristics. The High-resolution Echelle Spectrograph (HESP) observations on the Himalayan Chandra Telescope (HCT) revealed distinct emission lines in various molecular bands of the comets (Figure 3).

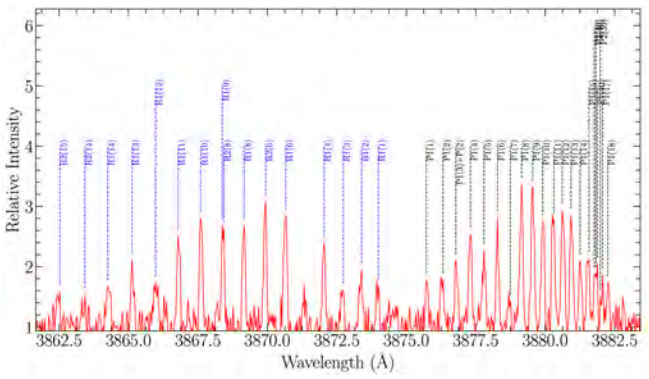

Figure 3: Cross identification of the rotationa transitions present in the CN ($B^2\Sigma^+$-$X^2\Sigma^+$)(0-0) band of comet 46P observed on 2018-11-28. Blue dashed lines mark the emission lines belonging to the *R* branch, while the black dashed lines mark those belonging to the *P* branch.

Analysis of the emission strengths along the comets' orbits showcased variations, providing insights into the composition and evolution of these icy bodies. The study successfully resolved green and red doublet forbidden oxygen lines in comets C/2015 V2, 46P, and 41P, enabling the computation of intensities and intrinsic line velocities for further analysis. The results of this study underscore the importance of medium and high-resolution optical spectroscopy in advancing our understanding of cometary bodies. By determining the Ortho-to-Para-Ratio of NH_3 (Ammonia) and Green-to-Red Doublet ratio in comet 46P and highlighting the significance of detailed modeling techniques, the study sets the stage for future research on cometary studies. Further investigations are warranted to explore the variations in emission strengths and ratios among different comets, offering valuable insights into the early history and composition of the Solar system's building blocks.

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This work has been done in collaboration with Kumar Venkataramani from CalTech, USA and Thirupathi Sivarani, Athira Unni and Devendra Sahu from the Indian Institute of Astrophysics, Bangalore.

(K. Aravind and Shashikiran Ganesh)

Long-term spectroscopic monitoring of comet 46P/Wirtanen

Comet 46P/Wirtanen's 2018 close encounter with Earth provided a unique opportunity for extensive spectroscopic observations. The gases emitted by the comet, such as CN, C_2, C_3, and NH_2, were analysed to understand its nucleus composition (Figure 4).

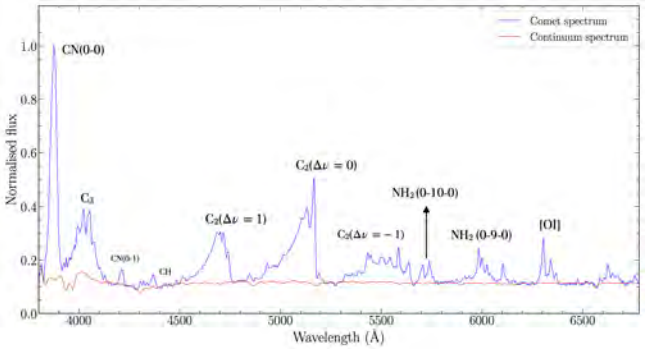

Figure 4: Optical spectrum of Comet 46P/Wirtanen observed on 2018-12-13 using the LISA spectrograph.

The comet displayed significant activity during this close approach, especially in its inner coma. The study revealed a consistent coma composition across different epochs, indicating a homogenous nucleus composition. Further research focusing on NH_2 and NH emissions is crucial to enhance our understanding of their parent sources. This investigation sheds light on the comet's consistent out-gassing behaviour across various apparitions, highlighting the importance of studying cometary activity during close approaches to Earth.

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This work has been done in collaboration with Kumar Venkataramani (CalTech) and the TRAPPIST group: Emmanuel Jehin (University of Liege, Belgium) and Youssef Moulane (University of Liege, Belgium) under the Indo-Belgium BIPASS project.

(K. Aravind and Shashikiran Ganesh)

Understanding the relative importance of magnetic field, gravity, and turbulence in star formation at the hub of the giant molecular cloud G148.24+00.41

The relative importance of magnetic fields (B-fields), turbulence, and gravity in the early phases of star formation is still not well understood. The plane of sky component of the magnetic field can be traced indirectly using the dust polarization of background starlight. We report the first high-resolution dust polarization observations at 850 μm around the most massive clump, located at the hub of the Giant Molecular Cloud G148.24+00.41, using SCUBA-2/POL-2 at the James Clerk Maxwell Telescope. We find that the degree of polarization decreases steadily towards the denser portion of the cloud with a power-law index of -0.6. Comparing the intensity gradients and local gravity with the magnetic field orientations, we find that local gravity plays a dominant role in driving the gas collapse as the magnetic field orientations and gravity vectors seem to point towards the dense clumps. A better correlation of intensity gradients with the B-fields tells that matter is following the B-field lines or vice-versa. We also find evidence of U-shaped magnetic field morphology towards a small-scale elongated structure associated with the central clump, hinting at converging accretion flows towards the clump. Our observation has resolved the massive clump into multiple substructures. We study the magnetic field properties of two regions (Figure 5), central clump (CC) and northeastern elongated structure (NES).

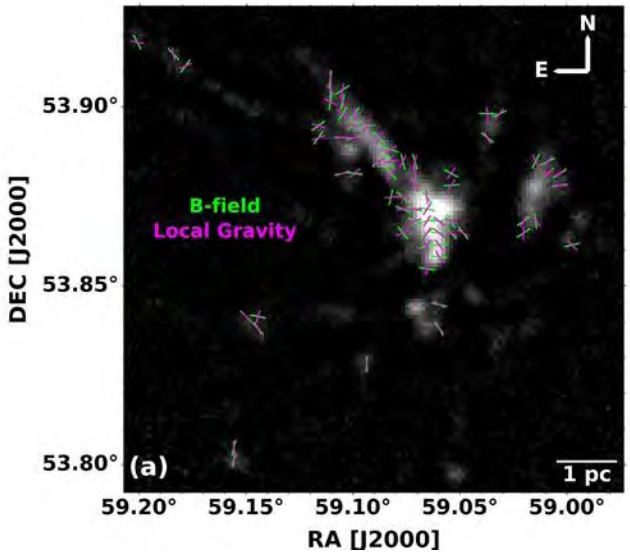

Figure 5: The image displays the orientation of the magnetic field (green lines) and local gravity vectors (pink lines) on the cold dust emission at 850 microns. For details see Figure 8 of Rawat et al. (2024).

Using the modified Davis–Chandrasekhar–Fermi method, we determine that the magnetic field strengths of CC and NES are $\sim$ 24.0 $\pm$ 6.0 μG and 20.0 $\pm$ 5.0 μG, respectively. The mass-to-flux ratios are found to be magnetically transcritical/supercritical, while the Alfvén Mach number indicates a trans-Alfvénic state in both regions. These results, along with Virial analysis, suggest that at the hub of G148.24+00.41, gravitational energy has an edge over magnetic and kinetic energies.

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This work has been done in collaboration with Chakali Eswaraiah Indian (IISER, Tirupati), Jia-Wei Wang (ASIAA, Taiwan), Davide Elia (IAPS, Italy), and other national and international collaborators.

(Vineet Rawat and Manash Samal)

Deciphering the Hidden Structures of HH 216 and Pillar IV in M16: Results from JWST and HST

High-resolution and high-sensitivity near-infrared and mid-infrared observations from the James Webb Space Telescope (*JWST*) allow the study of the dust and gaseous structures around embedded protostars. This can enable us to gain a better understanding of physical processes taking place in star-forming sites. The *JWST* facility has mapped the "Pillars of Creation" or "elephant trunks" in the Eagle Nebula (M16; distance $\sim$1.74 pc), which has been regarded as a site of active star formation. To probe the star formation processes, the *JWST* infrared images are employed toward the Pillar IV and an ionized knot HH 216 in M16. Pillar IV is known to host a Class I protostar that drives a bipolar outflow. The outflow has produced the bow shock, HH 216, which is associated with the red-shifted outflow lobe. HH 216 is traced with the 4.05 μm Br-alpha and the radio continuum emission; however, it is undetected with molecular hydrogen (H_2) emission at 4.693 μm. HH 216 seems to be associated with both thermal and non-thermal radio emissions. High-resolution images from the Hubble Space Telescope (HST) and the JWST reveal entangled ionized structures (below 3000 AU) of HH 216. The *JWST* images (resolution $\sim$0.07-0.7 arcsec) reveal the protostar as a single, isolated object (below 1000 AU). New knots in 4.693 μm H_2 emission are detected and are mainly found on Pillar IV's northern side. This particular result supports the previously proposed episodic accretion in the powering source of HH 216. One part of the ionized jet (extent $\sim$0.16 pc) is discovered on the southern side of the driving source. Based on the analysis of the molecular line data, observational signposts of cloud-cloud collision (or interacting clouds) towards Pillar IV are investigated. Overall, our results suggest that the interaction of molecular cloud components around 23 and 26 km s^{-1} might have influenced star formation activity in Pillar IV.

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This work was done in collaboration with Saurabh Sharma (ARIES, India), M. Padovani (INAF, Italy), T. Baug (SNBNCBS, India), and Y. D. Mayya (INAOE, Mexico).

(L. K. Dewangan, O. R. Jadhav, A. K. Maity, N. K. Bhadari and R. Pandey)

Galactic 'Snake' IRDC G11.11-0.12: a site of multiple hub-filament systems and colliding filamentary clouds

The past decade has witnessed a significant improvement in understanding the formation processes of massive OB-stars (M $>$ 8 $M_{\odot}$). However, the underlying physical mechanisms for the mass transfer (or mass accumulation) from parsec-scale clumps to cores in massive star formation research are still unknown. Such processes can be studied in infrared dark clouds (IRDCs) or elongated dust filaments as absorption feature at infrared wavelengths, and dust/molecular filaments in emission hosting hub-filament systems. The present work focuses on the 'Snake' nebula or G11.11$-$0.12 (hereafter, G11; distance $\sim$2.92 kpc; length $\sim$27 pc), which is one of the well explored filamentary IRDCs using multi-wavelength data sets. The IRDC G11 is prominently evident in the *Spitzer* 8.0 μm image. *Spitzer* images hint at the presence of sub-filaments (in absorption), and reveal four infrared-dark hub-filament system candidates (extent $<$ 6 pc) toward G11, where massive clumps ($>$ 500 $M_{\odot}$) and protostars are identified. The ^{13}CO(2–1), C^{18}O(2–1), and NH_3(1,1) line data reveal a noticeable velocity oscillation toward G11, as well as its left part (or part-A) around radial velocity (V_{lsr}) of 31.5 km s^{-1}, and its right part (or part-B) around V_{lsr} of 29.5 km s^{-1}. The common zone of these cloud components is investigated toward the center of G11 housing one hub-filament system. Each cloud component hosts two sub-filaments. In comparison to part-A, more APEX Telescope Large Area Survey of the Galaxy (ATLASGAL) clumps are observed toward part-B. High-resolution near-infrared images from the James Webb Space Telescope *JWST* discover one infrared-dark hub-filament system candidate (extent $\sim$0.55 pc) around the massive protostar G11P1 (i.e., G11P1-HFS). Hence, the infrared observations reveal multiple infrared-dark hub-filament system candidates at multi-scale in G11. The Atacama Large Millimeter/submillimeter Array (ALMA) 1.16 mm continuum map shows multiple finger-like features (extent $\sim$3500–10000 AU) surrounding a dusty envelope-like feature (extent $\sim$18000 AU) toward the central hub of G11P1-HFS. Signatures of forming massive stars are found toward the center of the envelope-like feature, where embedded near-infrared sources associated with radio continuum emission are located ($<$ 8000 AU scale). The ALMA $H^{13}CO^{+}$ line data show two cloud components with a velocity separation of $\sim$2 km s^{-1} toward G11P1. Overall, the multi-scale physical processes are investigated in the G11 site presenting it as a unique target hosting multiple hub-filament systems.

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This work was done in collaboration with C. Eswaraiah (IISER Tirupati, India) and Saurabh Sharma (ARIES, India).

(L. K. Dewangan, N. K. Bhadari, A. K. Maity and O. R. Jadhav)

Fragmentation and dynamics of dense gas structures in the proximity of massive protostar W42-MME

The formation process of massive stars (M $>$ 8 $M_{\odot}$), which immensely impact Galaxy evolution through their strong radiative and mechanical feedback, is an unsolved puzzle in astrophysics. It is now believed that massive stars form in a dense massive hub originated from converging parsec-scale gas filaments (i.e., hub-filament system). The fragmentation of molecular clouds into cores and ultimately stars is primarily driven by the interplay between self-gravity and turbulence across various physical scales. Investigating the role of gravity and turbulence in the early stages of star formation is one of the hot topics in star formation research. Utilizing the high-resolution (0.31 arcsec $\times$ 0.25 arcsec) Atacama Large Millimeter/submillimeter Array (ALMA) dust continuum and molecular line data, this work explores the fragmentation and dynamics of gas inside a hub-filament system in the W42 region. The region is known to host a massive protostar, W42-MME. We performed a dendrogram analysis of ALMA $H^{13}CO^{+}$ (4–3) line data to study multi-scale structures and their spatio-kinematic properties, and analyzed the fragmentation and dynamics of dense structures down to $\sim$2000 AU scale. The observational results show that the self-gravity of collapsing structures ($<$ 20,000 AU) can increase the gas velocity dispersion (or turbulence) and mimic Larson's dispersion-size relation at constant column density. Overall, our findings provide observational support for the hierarchical and chaotic collapse scenario in the vicinity of the massive protostar W42-MME, emphasizing the role of gravity-driven turbulence.

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This work was done in collaboration with L. E. Pirogov (IAP RAS, Russia), A. G. Pazukhin (IAP RAS, Russia), I. I. Zinchenko (IAP RAS, Russia) and Saurabh Sharma (ARIES, India).

(N. K. Bhadari, L. K. Dewangan and A. K. Maity)

New insights in the bubble wall of NGC 3324: intertwined sub-structures and a bipolar morphology uncovered by JWST

Massive stars (M $>$ 8 $M_{\odot}$) play a crucial role in shaping the interstellar environment through the release of substantial radiative and mechanical feedback. Despite the significance of these contributions, our understanding of the underlying processes remains incomplete. The high-resolution and high-sensitivity data from the James Webb Space Telescope (*JWST*) offer a unique opportunity to gain deeper insights into these physical processes. In this context, one of the primary science objectives of *JWST* is to study the anatomy of photodissociation regions surrounding ionized regions (known as HII regions) driven by massive stars. To achieve this objective, we focused our study on the Galactic bubble NGC 3324, situated at a distance of 2.2 kpc. Two massive stars have been identified as the major ionizing sources of NGC 3324.

We report the discovery of intertwined substructures toward the bubble wall of NGC 3324 below a physical scale of 4500 AU, at the interface between the HII region and the molecular cloud. Star formation signatures (i.e., the presence of young stellar objects and molecular outflows) have mostly been traced on one side of the ionization front, which lies on the molecular cloud's boundary. The elongated structures are associated with the 3.3 μm polycyclic aromatic hydrocarbon (PAH) emission, the 4.05 μm ionized emission, and the 4.693 μm H_2 emission. However, the PAH-emitting structures are depicted between the other two. The continuum-subtracted H_2 emission reveals numerous intertwined substructures that are not prominently traced in the 3.3 μm PAH emission. The separation between two substructures in the H_2 emission is $\sim$2420 AU. The intertwined substructures are delineated in spatial regions corresponding to the transition zone from neutral to H_2, indicating that

these structures originate from a force imbalance between thermal and ram pressure. This imbalance leads to an instability commonly referred to as "thin-shell" instability. Moreover, high-resolution of *JWST* images has revealed a bipolar HII region driven by a candidate massive star.

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This work was done in collaboration with Y. D. Mayya (INAOE, Mexico), S. Bhattacharyya (CHRIST University, India), Saurabh Sharma (ARIES, India) and G. Banerjee (CHRIST University, India).

(L. K. Dewangan, A. K. Maity and N. K. Bhadari)

AFGL 5180 and AFGL 6366S: sites of hub-filament systems at the opposite edges of a filamentary cloud

Massive stars (M $>$ 8 $M_{\odot}$) are known for their tremendous radiative and mechanical feedback, which allow them to play a vital role in the evolution of their host galaxies. Despite their importance, the formation mechanism of massive stars is not yet fully understood. It is thought that massive stars and clusters of young stellar objects commonly form within parsec-scale massive clumps/clouds such as hub-filament systems that are known as a junction of three or more dust and molecular filaments. The incoming material from very large-scales of 1-10 pc may be funnelled along molecular filaments into the central hubs in hub-filament systems. Recent theoretical works suggest that hub-filament systems can be developed through cloud-cloud collision, but observational evidence is required to validate this idea.

Nearby ($\sim$1.5 kpc) massive star-forming sites AFGL 5180 and AFGL 6366S are studied using multi-wavelength data sets, and these sites are located at opposite edges of a filamentary molecular cloud (length $\sim$5 pc) as traced using the ^{13}CO(J=1-0) line data. The radio continuum map at 8.46 GHz reveals a small cluster of radio sources toward AFGL 5180. Each site hosts the Class II 6.7 GHz methanol maser emission, which has been known as the signatures of the early stages of massive star formation. Using the near-infrared photometric data, the spatial distribution of young stellar objects is found toward the entire filament, primarily clustered at its edges. Using the *Herschel* 160 μm dust continuum image, a hub-filament system is investigated toward both the sites. The ^{13}CO(J=1-0) line data reveal the presence of two clouds with velocity ranges of approximately [$-$3.1, 4.8] and [5.8, 12.9] km s^{-1}. Notably, these clouds are interconnected by an intermediate velocity bridge feature. Furthermore, the "key/intensity-enhancement" and "keyhole/intensity-depression" features of the two clouds are identified, showing the presence of a complementary distribution. This correspondence is further enhanced, when considering a spatial shift of approximately 2.3 pc in the red cloud component. The observed bridge feature and the complementary distribution together show the onset of the cloud-cloud collision process in the selected target sites. The relative velocity between the cloud components and the spatial shift observed in their complementary distribution reveals a collision time scale of about 1 million years ago. Based on the observed outcomes, it is reasonable to propose that a collision between the molecular clouds seeded the formation of hub-filament systems and the massive stars toward both the target sites.

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This work was done in collaboration with D. K. Ojha (TIFR, India) and Z. Chen (PMO, CAS, China).

(A. K. Maity, L. K. Dewangan, N. K. Bhadari and R. Pandey)

Star-forming site RAFGL 5085: Is a perfect candidate of hub-filament system ?

The role of radiative and mechanical feedback of massive OB stars ($>$ 8 $M_{\odot}$) on the physical environment of their host galaxies has been well known in the literature. However, despite a great deal of progress in recent years, our understanding on the origin of such massive stars is still incomplete. To explain the formation of massive stars, two popular theories, which are the core-fed scenario and the clump-fed scenario, are available in the literature. The core-fed scenario (or monolithic collapse model) supports the existence of massive prestellar cores, where massive stars can form. The clump-fed scenario favours that massive stars are assembled by inflow material from large scales of 1–10 pc clouds outside the cores. In order to observationally study the formation of massive stars, one needs to explore the embedded morphology and the gas motion around a newly formed massive star that may hold clues to its origin.

The selected target site in this work is a massive star-forming region, RAFGL 5085/IRAS 02461+6147/ G136.3833+02.2666, which is located at a distance of 3.3 kpc. To investigate the star formation process, we present a multi-wavelength study of a massive star-forming site RAFGL 5085, which has been associated with the molecular outflow, HII region, and near-infrared cluster. The continuum images at 12, 250, 350, and 500 μm show a central region (having M_{clump} $\sim$225 $M_{\odot}$) surrounded by five parsec-scale filaments, revealing a hub-filament system (not shown here). In the *Herschel* column density ($N(H_2)$) map, filaments are identified with higher aspect ratios (length/diameter) and lower $N(H_2)$ values ($\sim$0.1–2.4 $\times 10^{21}$ cm^{-2}), while the central hub is found with a lower aspect ratio and higher $N(H_2)$ values ($\sim$3.5–7.0 $\times 10^{21}$ cm^{-2}). The central hub displays a temperature range of [19, 22.5] K in the *Herschel* temperature map, and is observed with signatures of star formation (including radio continuum emission). The JCMT ^{13}CO(J= 3–2) line data confirm the presence of the hub-filament system and its hub is traced with supersonic and non-thermal motions having higher Mach number and lower thermal to non-thermal pressure ratio. In the ^{13}CO position-velocity diagrams, velocity gradients along the filaments toward the hub-filament system appear to be observed, suggesting the gas flow in the RAFGL 5085 hub-filament system and the applicability of the clump-fed scenario.

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This work was done in collaboration with Saurabh Sharma (ARIES, India), T. Baug (SNBNCBS, India), and C. Eswaraiah (IISER Tirupati, India).

(L. K. Dewangan, N. K. Bhadari, A. K. Maity and R. Pandey)

The Giant Molecular Cloud G148.24+00.41: gas properties, kinematics, and cluster formation at the nexus of filamentary flows

A group of stars that are gravitationally bound to one another is called a star cluster. It is believed that in a molecular cloud, the majority of the stars, if not all, form in clusters. The crowded environment of the clusters in which stars form determines the properties of stars themselves and likely their planetary properties. Simulations suggest that in the vast expanses of the cosmos, intricate structures and their gas properties and kinematics shape the birth and evolution of stellar clusters. In this work, we did a comprehensive investigation of the gas properties and kinematics of the Giant Molecular Cloud "G148.24+00.41" of our own Galaxy. Using observations of CO (1-0) isotopologues, this work finds that the cloud is massive (10^5 $M_\odot$) and is one of the most massive clouds of the outer Galaxy. We identified six likely velocity coherent river-like filaments in the cloud having length, width, and mass in the range of 14–38 pc, 2.5–4.2 pc, and (1.3–6.9) $\times$ 10^3 $M_\odot$, respectively. Also, we find that the filaments are converging towards the central area of the cloud (Figure 6), and the longitudinal accretion flows along the filaments are in the range of $\sim$26–264 $M_\odot$ Myr^{-1}.

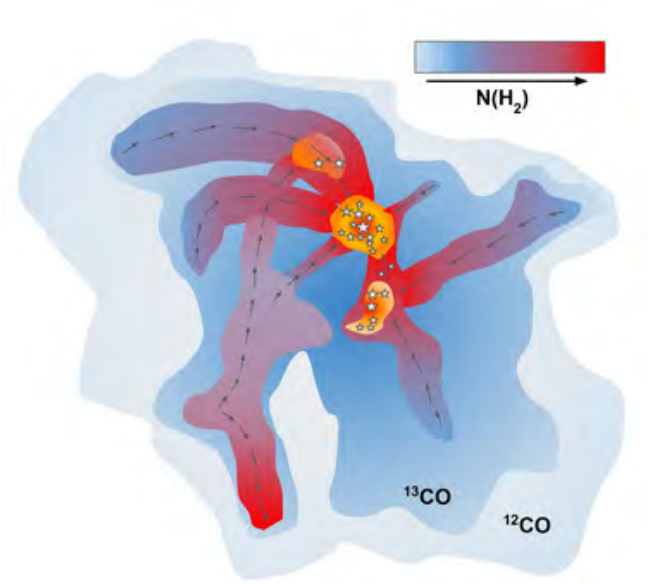

Figure 6: Cartoon illustrating see the structure and kinematics of the gas of the molecular cloud G148.24+00.41 and the formation of star clusters at the nexus of the river-like filamentary flows. Details can be found in Rawat et al. 2024.

The cloud has fragmented into seven clumps having gaseous mass in the range of $\sim$ 260–2100 $M_\odot$ and an average size of around $\sim$1.4 pc, out of which the most massive clump is located near the geometric centre of the cloud. Three filaments are found to be directly connected to the massive clump and transferring cold gaseous matter at a rate of $\sim$675 $M_\odot$ Myr^{-1}. We find that the central clump is host to a young embedded cluster, seen in infrared. From these findings, we conclude that large-scale river-like converging filamentary flows towards the central region of the collapsing cloud, is an important mechanism in supplying the matter necessary to form the central high-mass gaseous clump and subsequent stellar cluster.

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This work has been done in collaboration with D.L Walker (Jodrell Bank Centre for Astrophysics, Manchester, UK), D.K. Ojha (TIFR, Mumbai) A. Tej (IIST, Thiruvananthapuram), and other national and international collaborators.

(Vineet Rawat, Manash Samal and Ekta Sharma)

The statistical analysis of the dynamical evolution of the open clusters

The majority of the stars, if not all, are considered to be formed in the clustered environment of molecular clouds. Those that survive cloud dispersal and remain gravitationally bound are seen as open clusters, with tens to thousands of member stars. As a cluster evolves, its evolution is governed by the interaction among the cluster members as well as the gravitational pull of the Galactic potential. In this work, we studied the dynamical evolution of ten open clusters. These clusters include both young and intermediate-age open clusters with ages ranging from 25 $\pm$ 19 Myr to 1.78$\pm$0.20 Gyr. The total mass of these clusters ranges from 356.18$\pm$142.90 to 1811.75$\pm$901.03 $M_\odot$.

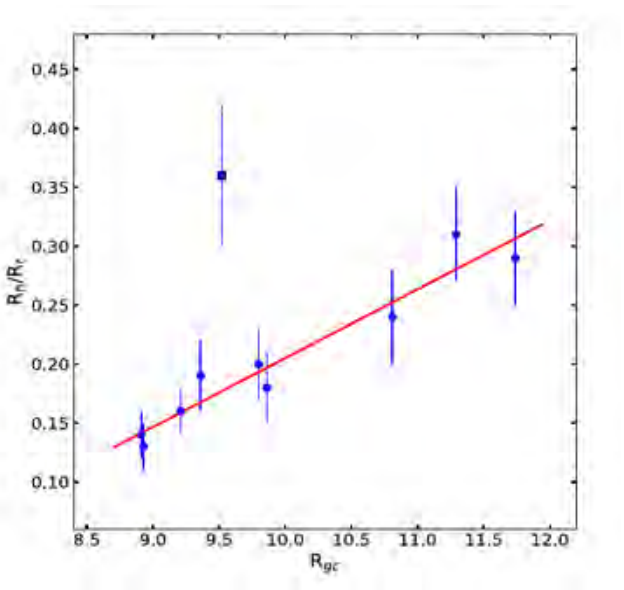

Figure 7: The plot shows the change in ratio of half-mass radius (R_h) to tidal radius (R_t) of the studied cluster with respect to their distance from the Galactic center (R_{gc}).

The Galactocentric distances to the clusters are in the range of 8.91$\pm$0.02 – 11.74$\pm$0.18 kpc. The study is based on the ground-based UBVRI data supplemented by the astrometric data from the Gaia archive. The mass segregation in these clusters was quantified by mass segregation ratios (MSR) calculated from the mean edge length obtained through the minimum spanning tree method using the member stars. The clusters NGC 2360, NGC 1960, IC 1442, King 21 and SAI 35 have MSR to be 1.65 $\pm$ 0.18, 1.94 $\pm$ 0.22, 2.21 $\pm$ 0.20, 1.84 $\pm$ 0.23 and 1.96 $\pm$ 0.25, respectively, which indicate moderate mass segregation in these clusters. The remaining five clusters are found to exhibit weak or no mass segregation. We used the ratio of half mass radius to the tidal radius, i.e., R_h /R_t to

investigate the effect of the tidal interactions on the cluster structure and dynamics. The ratios of half mass radii to tidal radii are found to be positively correlated (Figure 7) with the Galactocentric distances with a linear slope of 0.06 $\pm$ 0.01 having linear regression coefficient r-square = 0.93 for the clusters. Our analyses suggest that the Galactic potential has played a significant role in the evolution of these clusters.

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This work has been done in collaboration with Y. C. Joshi (ARIES, Nainital) and A. S. Gour (Ravishankar Shukla University, Raipur).

(Jayanand Maurya, Manash Samal and Vineet Rawat)

Tracing the Outer spiral arm of the Milky Way using red clump stars

Understanding the formation and evolution of the galaxies has been a topic of interest for centuries. Studying the Milky Way provides a unique advantage, allowing us to investigate individual stars in great detail due to our favorable position within the galaxy. The structure of the Milky Way disk is characterized by the presence of spiral arms in the disk region. Disk features have been studied thoroughly using various populations in the past few decades, primarily focusing on the younger (Myr) tracers. While extensive research has been conducted to understand the structure of the Milky Way disk using younger tracers, the dedicated investigation focusing on the identification of disk features specifically from the distribution of RC stars (intermediate-to-old age population) is limited.

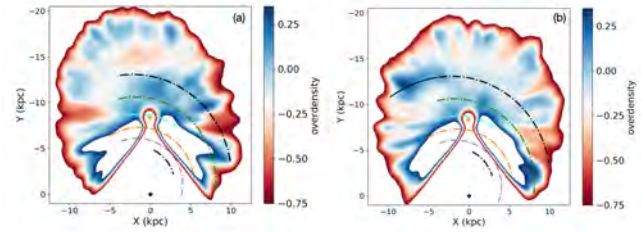

Figure 8: Overdensity map of red clump stars above (Z $>$ 0) and below (Z $<$ 0) the Galactic plane in panels (a) and (b), respectively. Spiral arms from the literature (Scutum: purple, Sagittarius: orange, Local: cyan, Perseus: green, and Norma-Outer: black) are over-plotted as dash-dotted lines. The solid black line in panel (b) corresponds to the extension of the Outer arm in the third Galactic quadrant. Plus sign denotes the Galactic center and orange dot corresponds to the position of the Sun.

In this study, we used 20-year-old Two Micron All Sky Survey (2MASS) data to systematically extract the red clump stars from the color-magnitude diagrams and refined the selection using data from the Gaia mission. We have provided the largest sample of red clump stars now available in the literature, with 8.8 million stars covering the Galactic plane with a range of $40^\circ \leq \ell \leq 320^\circ$ and $-10^\circ \leq b \leq 10^\circ$. The distribution of the selected red clump stars revealed the presence of the poorly constrained Outer arm of the Galaxy with an extension of 6kpc long feature in comparison to the earlier known limits. Furthermore, our study provided direct observational evidence of the warping of the spiral arms as depicted by the overdensity map of red clump stars above and below the Galactic plane (shown in Figure 8).

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This work has been done in collaboration with Mathias Schutheis, Lagrange Laboratory, Université Côte d'Azur, Nice, France.

(Namita Uppal and Shashikiran Ganesh)

Warp and flare of the old Galactic disc from the red clump stars

The structure of the Milky Way disk is characterized by the presence of spiral arms in its inner regions, while the outer regions exhibit flare and warp features. In this study, we investigated the outer structure of the Galaxy using red clump stars. The distribution of red clump stars reveals a significant disc flaring, where the scale height of the disc increases from 0.38 kpc in the solar neighborhood to ~ 2.2 kpc at $\mathrm{R} = 15$ kpc. The analyses confirm the wrapping of the outer disk of our galaxy with noticeable north-south asymmetry. Based on the red clump sample, the warp can be modeled with $\mathrm{Z}_w = (0.0057 \pm 0.0050)[\mathrm{R} - (7358 \pm 368)(pc)]^{1.40\pm0.09} sin(\phi - (-2^\circ.03 \pm 0^\circ.18))$. The comparison of the detected flare (left panel of Figure 9) and warp (right panel of Figure 9) in the outer regions of the Galactic disk from red clump stars with the younger population presents strong constraints on the Galaxy evolution models.

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This work has been done in collaboration with Mathias Schutheis, Lagrange Laboratory, Université Côte d'Azur, Nice, France

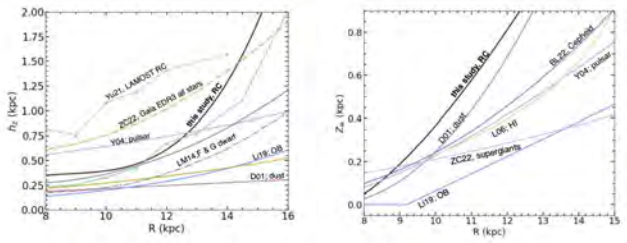

Figure 9: Variation of scale height (h_z) and disk height (Z_w) with Galactocentric distance (R) in the left and right panels, respectively. The comparison of the disk flare and warp of our study (black line) with the other tracers is shown by different colors.

(Namita Uppal and Shashikiran Ganesh)

Exploring the short-term variability of H_α and H_β emissions in a sample of M dwarfs

The time-scales of variability in active M dwarfs can be related to their various physical parameters. Thus, it is important to understand such variability to decipher the physics of these objects. In this study, we have performed the low resolution (∼5.7 Å) spectroscopic monitoring of 83 M dwarfs (M0–M6.5) to study the variability of H_α/H_β emissions;

over the time-scales from ∼0.7 to 2.3 h with a cadence of ∼3–10 min. Data of a sample of another 43 late-type M dwarfs (M3.5–M8.5) from the literature are also included to explore the entire spectral sequence. 53 of the objects in our sample (∼64 %) show statistically significant short-term variability in H_α. We show that this variability in 38 of them are most likely to be related to the flaring events. We find that the early M dwarfs are less variable despite showing higher activity strengths (L_{H_α}/L_{bol} and L_{H_β}/L_{bol}), which saturates around ∼10–3.8 for M0–M4 types. Using archival photometric light curves from TESS and Kepler/K2 missions, the derived chromospheric emission (H_α and H_β emission) variability is then explored for any plausible systematics with respect to their rotation phase. The variability indicators clearly show higher variability in late-type M dwarfs (M5–M8.5) with shorter rotation periods (<2 d). For 44 sources, their age has been estimated using StarHorse project and possible correlations with variability have been explored. The possible causes and implications for these behaviours are also discussed.

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This work has been done in collaboration with José G Fernández-Trincado of Instituto de Astronomia, Universidad Catolica del Norte, Antofagasta, Chile and A. B. A. Queiroz of Leibniz-Institut für Astrophysik Potsdam (AIP), Potsdam, Germany.

(Vipin Kumar, A. S. Rajpurohit and Mudit K. Srivastava)

Formation of Carbon monoxide and Dust in the ejecta of a Recurrent Nova V745 Sco

A classical nova eruption results from a thermonuclear runaway (TNR) on the surface of a white dwarf (WD) accreting material from a companion star in a close binary system. We analyzed the near-infrared spectrum of V745 Sco obtained 8.7 days after its 2014 outburst. The K band near-infrared spectrum was clearly showing enhancement in emission at and after 2.29 μm suggesting the formation of Carbon monoxide molecules in the ejecta of the nova (Figure 10). The mass and temperature of the CO and dust are estimated to be T_{CO} = 2250 $\pm$ 250 K, M_{CO} = (1-5) $\times$ 10^{-8} $M_\odot$, and T_{dust} = 1000$\pm$50 K, M_{dust} ∼10^{-8}–10^{-9} $M_\odot$, respectively. Dust also appears to have formed in the ejecta around the time that CO was detected. High-cadence NIR light curve between days 8 and 11 shows a clear bump in the K band and also in the H band albeit to a lesser extent. We interpret this IR excess as emission by dust. This interpretation is consistent with the simultaneous appearance of CO. All novae that have shown CO in emission have invariably proceeded to form dust. The lifespan of the dust emission in V745 Sco is short with the bump disappearing within a few days. Grain destruction may be by sputtering by high-energy particles that diffuse across the shock fronts into the neutral zone or by the soft X-ray flux. This is the first ever report of the formation of molecules or dust in the ejecta of a recurrent nova. The detection of CO and dust was made when the conditions are expected to be hostile for molecule or dust formation. At the time of their detection, the shocked gas was at a high temperature of about 10^7K as evidenced by the presence of coronal lines. The ejecta were simultaneously irradiated by a large flux of soft X-ray radiation from the central white dwarf. The temperature was very high and the radiation field was harsh, and in such an environment it appears unlikely that molecules could form or grains condense within the ejecta, they are like snowflakes in a furnace. However, in the radiative shock-driven model there exists a region where molecules and dust could potentially form. We show that as a shock is driven into the ejecta, molecule and dust formation can occur within the cool, dense shell created between the forward and reverse shocks. While the forward and reverse shocks have temperatures of 10^7 K and a few mega kelvins respectively, the intermediate clumpy shell is cool and dense enough due to radiative shock compression (particle density ∼10^{14} cm^{-3}) to allow CO formation and rapid dust nucleation. We thus propose the CO and dust seen in V745 Sco formed in this region. We speculate that this site may also be a region of particle acceleration, thereby contributing to the generation of γ-rays.

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This work has been done in collaboration with Prof. C. E. Woodward (University of Minnesota, USA) and Aneurin Evans (Keel University, UK).

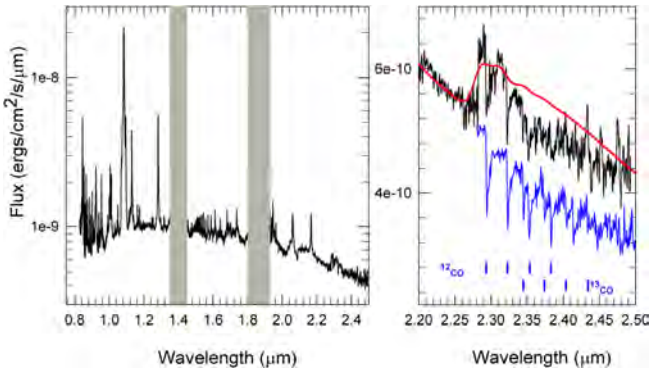

Figure 10: The left panel shows the entire NIR spectrum of V745 Sco 8.7 days after the 2014 eruption. The right panel shows a magnified view of the first overtone CO emission (black) superposed on the emission are the absorption bandheads of ^{12}CO and ^{13}CO (vertical ticks). The spectrum of a typical M6 III, HD 18191 (blue), is also included to show the expected CO absorption bandheads. The red line is an LTE model fit to the CO emission.

(D. P. K. Banerjee, Vishal Joshi and N. M. Ashok)

Estimating the dust properties in galactic nova V445 Puppis

V445 Puppis, the only known Galactic helium nova, is a unique test bed to verify supernova (SN) theories in the single-degenerate channel that involve a white dwarf (WD) accreting matter from a helium-rich donor. V445 Pup erupted in 2000 reaching a peak V brightness of 8.46 mag on 2000 November 29, and then slowly declined. V445 Pup appeared to be a slow nova except that the spectra, both in the optical and near-infrared, recorded in the immediate and posteruption, were unique in not showing the hydrogen lines conventionally seen in a nova outburst. Instead, there were many lines of carbon, helium, and other metals; the carbon and Helium lines were specially prominent in the NIR. Based on its spectrum, Ashok & Banerjee proposed in 2003 V445 Pup to be a helium nova that had undergone a thermonuclear runaway in helium-rich matter accreted onto a white dwarf's (WD) surface from a helium-rich donor. An estimate of the mass of the helium shell on the WD is crucial

to deciding whether or not it will undergo an SN detonation. We study this nova to estimate the dust and ejecta masses in the 2000 November eruption of V445 Pup. Subsequent to its outburst, the star became cocooned in a dust envelope. An analysis of the spectral energy distribution (SED) of the dust using infrared data shows that V445 Pup produced at least $10^{-3}M_{\odot}$ of dust, which is unprecedented for a classical or recurrent nova. The SED can be explained by a combination of a cold dust component at 105±10 K, mass (1.9±0.8) × $10^{-3}M_{\odot}$, and a warm dust component at 255±10 K, mass (2.2±1.2) × $10^{-5}M_{\odot}$ (Figure 11). Preexisting equatorial material, if dusty, would contribute to the hotter and less massive dust component. For a conservative choice of the gas-to-dust mass ratio in the range 10–100, the mass of the ejecta is estimated to be 0.01–0.1 $M_{\odot}$. Although the ejected mass in V445 Pup is unusually high for a nova, a helium nova outburst is still the most favorable interpretation for the 2000 eruption. The WD mass of V445 Pup is unknown but we speculate it is low based on the low amplitude outburst, the extremely long time to decline, the formation of dust, the amount of mass ejected, the low excitation spectrum at outburst and the lack of coronal line emission even 3 yr after outburst. A low mass could explain why an SN Ia explosion was averted by the double-detonation channel. V445 Pup also shares certain similarities with CK Vul, the latter proposed to belong to the class of objects known as intermediate-luminosity red transients (ILRTs) or interchangeably, luminous red novae.

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This work has been done in collaboration with Prof. C. E. Woodward (University of Minnesota, USA) and Aneurin Evans (Keel University, UK).

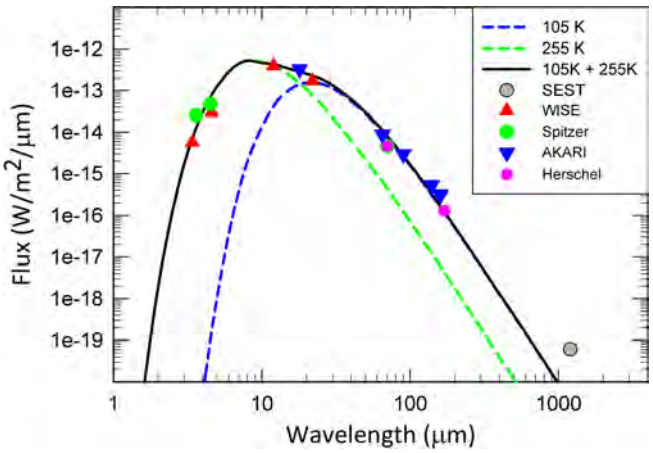

Figure 11: Model fit to the SED of V445 Pup using amorphous carbon grains. The black bold line is the composite of a 105 K (blue line) plus a 255 K(green line) components. The 1.2 mm point was not considered in the fitting.

(D. P. K. Banerjee and N. M. Ashok)

On the cyclotron absorption line and evidence of the spectral transition in SMC X-2 during 2022 giant X-ray outburst

Be/X-ray binaries represent two-thirds of the population of high mass X-ray binaries. The optical companion in BeXRBs is a non-supergiant OB spectral type star that shows Balmer series emission lines and infrared excess. Above characteristics originate from an equatorial circumstellar disk that is formed around the Be star due to its rapid rotation at velocities of more than 75% of Keplerian limit. The compact object in the system accretes directly from the Be-circumstellar disk. Two kinds of X-ray outbursts are observed from BeXRBs. First, Type-I outbursts are short (only a few weeks long), periodic events that reach a peak luminosity of $< 10^{37}$ erg s^{-1} and occur close to the periastron passage of the binary system. The second category of outbursts is giant in nature, where the peak luminosity reaches $> 10^{37}$–10^{38} erg s^{-1}. The latter usually lasts for a multiple or significant portion of the orbit. SMC X-2 is a 2.37 s pulsating source in a BeXRB system located inside the Small Magellanic Cloud (SMC) at a distance of 62 kpc. It was the second brightest X-ray source in the galaxy when SAS 3 discovered it in October 1977. Later observations with the HEAO, Einstein, and ROSAT missions demonstrated the X-ray transient nature of the source.

A comprehensive spectral and temporal studies of the Be/X-ray binary pulsar SMC X-2 is carried out using X-ray observations during the 2015 (NuSTAR and Swift/XRT observations) and 2022 (NICER and NuSTAR observations) outbursts. The pulse profile of the pulsar is unique and strongly luminosity dependent. It evolves from a broad-humped into a double-peaked profile above luminosity 3 × 10^{38} erg s^{-1}. The pulse fraction of the pulsar is found to be a linear function of luminosity as well as energy. Spectral evolution of the source is also investigated during the latest 2022 outburst with NICER. The observed photon index shows a negative and positive correlation below and above the critical luminosity, respectively, suggesting evidence of spectral transition from the subcritical to supercritical regime. The broad-band spectroscopy of four sets of NuSTAR and XRT/NICER data from both outbursts can be described using a cut-off power-law model with a blackbody component. In addition to the 6.4 keV iron fluorescence line, an absorption-like feature is clearly detected in the spectra. The cyclotron line energy observed during the 2015 outburst is below 29.5 keV, however, latest estimates in the 2022 outburst suggest a value of 31.5 keV. Moreover, an increase of 3.4 keV is detected in the cyclotron line energy at equal levels of luminosity observed in 2022 with respect to 2015. The observed cyclotron line energy variation is explored in terms of accretion induced screening mechanism or geometrical variation in line forming region.

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This work was done in collaboration with G. K. Jaisawal of National Space Institute, Denmark and other collaborators.

(Birendra Chhotaray and Sachindra Naik)

Hard X-ray polarization measurement for Cygnus X-1 with AstroSat/CZTI

Cygnus X-1 is the brightest and persistent black hole X-ray binary in our galaxy composed of a 21 solar mass black hole orbiting around a 40 solar mass O9.7 supergiant star. It is also the source of bipolar powerful ejections, therefore called a micro-quasar. The bipolar ejections or the jets are important to understand the accretion-ejection coupling in the black hole. Is the jet also a contributing factor to the observed hard X-ray emission? Resolving this question may lead to a significant improvement in our understanding of jet formation, energetics, magnetic field strength and geometry, as well as the

intricate interplay between the corona and the jet of the black hole. To arrive at the answer, however, one needs to measure the polarization of the X-ray emission. In the six decades since the birth of X-ray astronomy, there have only been 3 or 4 reports on X-ray polarization measurement of Cygnus X-1. In the new study conducted using observations from AstroSat's (Figure 12) Cadmium Zinc Telluride Imager (CZTI), we reported around 24% polarized high energy X-rays, strongly suggesting that the mechanism of X-ray emission more energetic than 200 keV is from the jet, possibly synchrotron radiation in an ordered magnetic field. Notably, the polarization of X-rays originating from the corona due to the scattering of local thermal radiation is expected to be less than 10%. Moreover, the CZTI detected high X-ray polarization only in the state that exhibits strong radio emission from the jet. For the first time, therefore, one can confirm the direct connection of the hard X-ray emission to the relativistic jet.

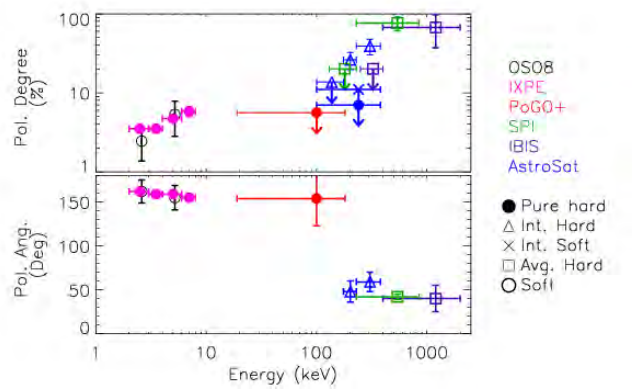

Figure 12: The figure summarises the Cygnus X-1 polarisation results with different satellites in different states of the source to date. The measurements using the AstroSat (plotted in blue) clearly shows the increasing trend in polarisation with energy. This figure is adapted from Chattopadhyay et al. (2024).

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This work was done in collaboration with T. Chattopadhyay (Stanford University), A.Rao, Yash Bhargava, Gulab Dewangan (IUCAA), Ajay Ratheesh (INAF-IAPS, Italy), Dipankar Bhattacharya (Ashoka University) and Varun Bhalerao (IIT Bombay).

(Abhay Kumar, S. Vadawale and N. P. S. Mithun)

Long-term Study of the First Galactic Ultraluminous X-Ray Source Swift J0243.6+6124 Using NICER

Ultraluminous X-ray sources (ULXs) are nonnuclear point-like X-ray sources observed in extragalactic regions that exhibit luminosities exceeding 10^{39} ergs s^{-1}. Initially, these X-ray sources were speculated to be intermediate-mass black holes. Later, it was observed that ULXs are stellar-mass black holes or neutron stars that are present in close binaries in which the donor fills the Roche lobe and accretion occurs in supercritical/super-Eddington mode. In 2014, the first ultraluminous X-ray pulsar (ULXP) was discovered, with coherent pulsations detected from the ULX M82 X-2. This finding provided a unique opportunity to study super-Eddington accretion onto magnetized neutron stars. Since then, several ULXPs have been detected, contributing to our understanding of these systems.

A remarkable transient X-ray outburst observed between 2017 and 2018 led to the discovery of Swift J0243.6+6124. This X-ray source is considered to be the first Galactic ULX due to its intense X-ray luminosity reaching up to an order of 10^{39} ergs s^{-1}. Timing investigations revealed that Swift J0243.6+6124 hosts a neutron star with a pulsation period of 9.8 s. Optical spectroscopic observations identified the companion star as an O9.5Ve-type star. The system is known to have a relatively short orbital period of around 28 days and a mildly eccentric orbit with an eccentricity(e) of approximately 0.1.

We carried out a detailed X-ray timing and spectral studies of Swift J0243.6+6124 during its giant and normal X-ray outbursts between 2017 and 2023 observed by the Neutron star Interior Composition Explorer (NICER). A distinct break is found in the power density spectra of the source. The corresponding break frequency and slopes of the power laws around the break vary with luminosity, indicating a change in the accretion dynamics with the mass accretion rate. Interestingly, we detected quasiperiodic oscillations within a specific luminosity range, providing further insights into the underlying physical processes. The spectral analysis was conducted comprehensively for the giant and all other normal outbursts. We identified a double transition at luminosities of $\sim$7.5 $\times$ 10^{37} and 2.1 $\times$ 10^{38} erg s^{-1} in the evolution of continuum parameters like the photon index and cutoff energy with luminosity. This indicates three distinct accretion modes experienced by the source, mainly during the giant X-ray outburst. A soft blackbody component with a temperature of 0.08–0.7 keV is also detected in the spectra. The observed temperature undergoes a discontinuous transition when the pulsar evolves from a sub- to super-Eddington state. Notably, in addition to an evolving 6–7 keV iron line complex, a 1 keV emission line was observed during the super-Eddington state of the source, implying X-ray reflection from the accretion disk or outflow material.

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This work was done in collaboration with G. K. Jaisawal of National Space Institute, Denmark and other collaborators.

(Birendra Chhotaray, Prantik Nandi, Neeraj Kumari and Sachindra Naik)

Investigation of an X-ray flaring event in NLS1 galaxy NGC 4051

Active galactic nuclei (AGNs) are believed to be powered by accretion onto the supermassive black holes that reside at the center of the galaxies. These are considered to be powerful sources (luminosities up to 10^{48} erg s^{-1}) in the Universe, which emit in the entire range of the electromagnetic spectrum. Ultraviolet/optical photons originating from a thermal accretion disc are inverse-Comptonized in the hot corona of relativistic electrons near the black hole and produce X-ray continuum emission, which can be approximated by a power law with an exponential cut-off. A fraction of the emitted X-ray photons from the corona is reflected in the surrounding materials, producing Fe K-line complex in 6–8 keV range and a reflection hump in 15–40 keV range. Additionally, an excess in the soft X-ray ($<$ 1 keV), known as soft-excess, is also observed. In AGNs, X-ray emission from the

corona is known to be highly variable. Short time scale variability is ubiquitous, with count rate changing by a factor of 2-3 in a few hours. Moreover, the AGNs have been seen transitioning from higher to lower flux states corresponding to the transition in the coronal structural changes.

We performed a detailed broad-band spectral and timing analysis of a flaring event of about 120 ks in the narrow-line Seyfert 1 galaxy NGC 4051 using simultaneous XMM-Newton and NuSTAR observations. The 300 ks long NuSTAR observation and the overlapping XMM-Newton exposure were segregated into pre-flare, flare, and post-flare segments. Using various physical and phenomenological models, we examined the 0.3–50 keV X-ray spectrum, which consists of a primary continuum, reprocessed emission, warm absorber and ultrafast outflows at different time-scales. From our analysis, we estimated the mass of the central black hole to be $\geq 1.32 \times 10^5$ solar-mass . The absence of correlation between the flux in the 6–7 keV and 10–50 keV bands suggests different origins of the iron emission line and the Compton hump. We found that the reflection fraction drops significantly during the flare, accompanied by an increase in the coronal height above the disc. The spectrum became soft during the flare, supporting the 'softer when brighter' nature of the source. After the alleviation of the flare, the coronal height drops and the corona heats up. This indicates that there could be inflation of the corona during the flare. We found no significant change in the inner accretion disc or the seed photon temperature. These results suggest that the flaring event occurred due to a change in coronal properties rather than any notable change in the accretion disc.

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This work was done in collaboration with A. Jana of Institute of Astronomy, National Tsing Hua University, Taiwan.

(Neeraj Kumari, Prantik Nandi and Sachindra Naik)

Survey of Bare Active Galactic Nuclei in the Local Universe ($z <$ 0.2). On the Origin of Soft Excess

Active Galactic Nuclei (AGNs) are one of the most energetic sources in the Universe. The extreme luminosity of the AGNs arises from the accretion of matter onto the super massive black holes (SMBHs). The accretion disk around the SMBH is the source of thermal photons that undergo inverse Compton scattering in a hot electron cloud called corona. It is possible to explore the innermost regions of the accretion disk and the corona using X-ray observations. The inverse Compton scattering of thermal photons produces a power-law spectrum with a cut-off in the X-ray band. A fraction of the coronal continuum photons could get reprocessed in the colder circumnuclear matter, like a dusty torus, broad-line region, and narrow-line region, producing several spectral features, such as absorption and emission lines in the broad-band spectrum.

The soft excess, an excess emission below 2 keV, is an extraordinary feature in the X-ray spectra for most Seyfert 1 AGNs. The origin of soft excess is one of the major open questions in AGN research. Historically, blackbody radiation from the accretion disk was used to model this radiation. Later, it was found that the characteristic temperature was much higher than the expected temperature from the standard disc. As an alternative explanation, the soft excess was attributed to reflection. Additionally, it is proposed that Comptonization in a warm, optically thick region surrounding the accretion disc could generate the soft excess. If a thermal blackbody generates the soft excess, then emission in the 0.5–2 keV range (soft excess) should lead to the 3–10 keV Comptonized primary continuum. However, this was observed in only some cases. These discoveries provoked the alternate origins of the soft excess.

The origin of the extraordinary feature in the soft X-ray band is investigated by considering a sample of 21 AGNs that have 'bare' nuclei. The space-based X-ray observatories such as XMM-Newton and Swift/XRT have observed these sources for a long time, and we considered the 0.5 to 10.0 keV band for this study. We considered the 0.5 to 2.0 keV band as soft excess emission, mostly dominated by the excess emission, and 3.0 to 10.0 keV as the primary continuum. The luminosities of the soft excess and primary continuum for the sample of sources are plotted in Figure 13. Here, we observe that these luminosities are highly correlated. From this study, we conclude that the observed correlation between the soft excess and primary continuum luminosities could have originated due to inverse Compton scattering in the Compton cloud, and both the luminosities depend on the accretion rate only.

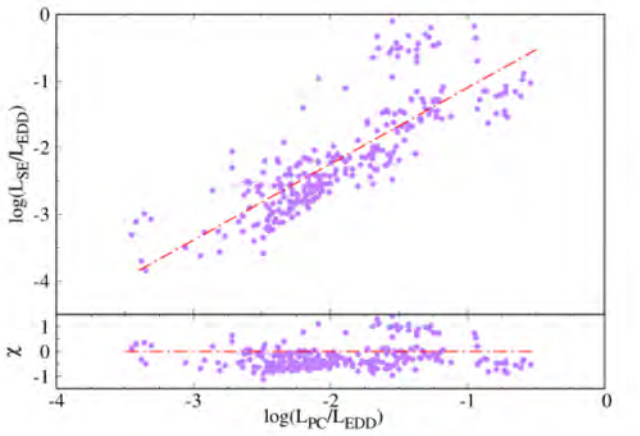

Figure 13: Correlation between the observed intrinsic luminosities of the primary continuum and soft excess for a sample of 21 bare AGNs. A linear fit is shown on the data set by the red dotted line, and corresponding variation of χ is also shown in the bottom panel.

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This work was done in collaboration with A, Chatterjee and S. Safi-Harb of University of Manitoba, Canada, A. Jana, and H. K Chang of Institute of Astronomy, National Tsing Hua University, Taiwan, and S. K. Chakrabarti of Indian Centre for Space Physics, Kolkata, India.

(Prantik Nandi and Sachindra Naik)

Long-term X-ray temporal and spectral study of a Seyfert galaxy Mrk 6

Active Galactic Nuclei (AGNs) are the extremely luminous and most persistent energetic sources in the Universe. This extreme luminosity is powered by mass accretion onto the supermassive black hole

residing at the centre of its host galaxy. The AGNs emit in the entire band of the electromagnetic spectrum. The X-ray emission from AGN is vital to probe the physical processes in extreme gravity as it is thought to originate from a high-temperature electron cloud called the corona, situated near the black hole. The X-ray spectrum of an AGN is primarily characterized by the power-law continuum emission produced through the inverse-Comptonization of the seed optical/UV photons from the standard accretion disc. The primary power-law continuum gets reprocessed in the accretion disc and/or molecular torus and produces a reflection hump above 10 keV, an iron emission line at $\sim$6.4 keV, and soft excess emission below 2 keV. Depending on the presence or absence of broad optical emission lines, the AGNs are classified as Types 1 or 2. Optical observations have identified a new subclass of AGNs called changing-look AGNs. These objects display the appearance or disappearance of the broad optical emission lines, switching from Type 1 to Type 2 and vice versa in a time-scale of months to decades. In X-rays, a different type of changing-look events are observed with the AGN switching between Compton-thin and Compton-thick states, known as changing-obscuration AGNs. Over the last decade, the number of such AGNs has grown up showing dramatic changes in spectral state and flux in optical as well as X-ray bands, e.g. UGC 4203, NGC 4151, NGC 2992, IC 751.

Markarian 6 (Mrk 6) is a nearby AGN that falls into the optical classification of an early-type S0 galaxy with the central black hole mass of $\sim$1.5 $\times$ 10^8. Considering its optical characteristics, Mrk 6 is commonly categorized as a Seyfert 1.5 AGN. However, it is noted that this source exhibits a "changing-look" behavior over time. A long-term X-ray study of Mrk 6 is carried out utilizing observations from XMM-Newton, Suzaku, Swift and NuSTAR observatories, spanning 22 years from 2001 to 2022. Mrk 6 is a relatively unexplored AGN that has exhibited "changing-look" behavior in optical observations. We found a complex correlation between the soft (0.5–3.0 keV) and hard (3.0–10.0 keV) X-ray light curves of this source. This result prompts a detailed investigation through spectral analysis, employing various phenomenological and physical models on the X-ray spectra. Based on the overall results obtained from X-ray spectroscopy, we found that the nature of the Compton cloud changed with time. Although Mrk 6 displays characteristics of a changing-look AGN from optical observations, our X-ray spectral analysis did not show any significant variation in the X-ray luminosity and Eddington ratio over a period of 22 years. This indicates that in the X-ray regime, the source did not show any change in its behavior during the observational period. We observed a complex variable structure of the obscuring absorber of Mrk 6, with two distinct types of partially absorbers: one neutral and the other ionized. Notably, the partially ionized absorber displays a dynamic behavior characterized by a rapid change in its location. This component extends towards the narrow line regions or the torus. Our observations trace this ionized hydrogen cloud component until the 2015 dataset, leading us to predict its disappearance between 2015 and 2019. Another component of the obscuring material, situated at a considerable distance from the central engine, remained relatively stable.

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This work was done in collaboration with A. Jana of Instituto de Estudios Astrofísicos, Facultad de Ingeniería y Ciencias, Universidad Diego Portales, Av. Ejército Libertador 441, Santiago, Chile.

(Narendranath Layek, Prantik Nandi, Neeraj Kumari, Birendra Chhotaray and Sachindra Naik)

AGN feedback through multiple jet cycles in Seyfert galaxy NGC 2639

To probe episodes to active galactic nuclei (AGN) jet/lobe activity we carried out radio observations of Seyfert galaxy NGC 2639 using upgraded Giant Metrewave Radio Telescope (uGMRT). NGC 2639 has been known to exhibit three episodes of AGN activity. Our sensitive uGMRT observations reveal a fourth episode of AGN activity by detecting 9.0 kpc radio lobes that are misaligned with the previously known 1.5 kpc, 360 pc, and 3 pc jet/lobe features (Figure 14). We find spectral ages of 9.0 kpc, 1.5 kpc, and 360 pc episodes to be nearly 34 Myr, 11 Myr, and 2.8 Myr, respectively. NGC 2639 shows a deficit of molecular gas in its central 6.0 kpc region. The GALEX NUV image also shows a deficiency of recent star formation in the same region, while the star formation rate surface density in NGC 2639 is lower by a factor of 5-18 compared to the global Schmidt law of star-forming galaxies. This makes NGC 2639 a rare case of a Seyfert galaxy showing episodic jet activity and possible signatures of jet-driven AGN feedback.

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This work has been done in collaboration with Ms. Vaishnav Rao from IIT Mumbai and Prof. Preeti Kharb from NCRA-TIFR, Pune.

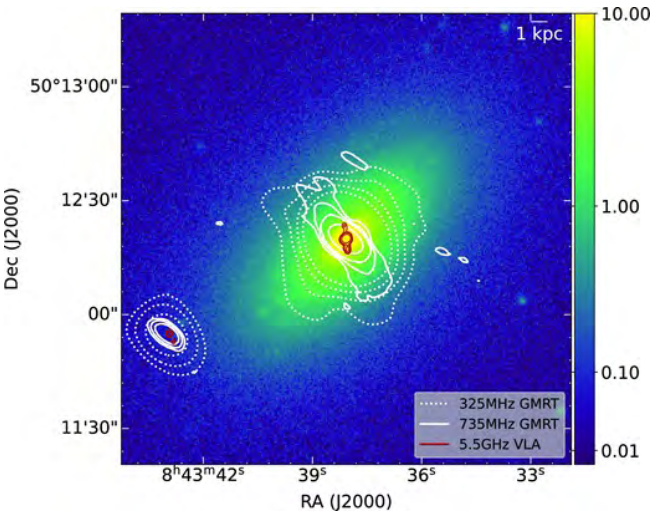

Figure 14: A radio-optical overlay of Seyfert galaxy NGC 2639 using SDSS r-band optical image and radio contours from 325 MHz GMRT (dotted contours), 735 MHz GMRT (solid contours) 5.5 GHz VLA (solid brown contours) imaging observations.

(Veeresh Singh)

Multi-epoch hard X-ray view of Compton-thick AGN in Circinus Galaxy

The circumnuclear material around active galactic nuclei (AGNs) is one of the essential components of the obscuration−based unification model. However, our understanding of the circumnuclear material in terms of its geometrical shape, structure, and its dependence on

accretion rate is still debated. We performed multi-epoch broad-band X-ray spectral modeling of a nearby Compton-thick AGN in Circinus galaxy. We utilize all the available hard X-ray ($>$ 10 keV) observations taken from different telescopes, *i.e.* *BeppoSAX*, *Suzaku*, *NuSTAR*, and *AstroSat*, at ten different epochs across 22 years from 1998 to 2020. To remove contribution from neighbouring off-nuclear sources we used *XMM−Newton* and *Chandra* observations of high angular resolution (Figure 15). The 3.0–79 keV broad-band X-ray spectral modeling using physically motivated models infers the presence of a torus with nearly edge-on view and a low covering factor of 0.28. The line-of-sight column densities in all the epochs are found to be Compton-thick ($N_{H,LOS}$ = 4.13–9.26 $\times$ 10^{24} cm^{-2}). The joint multi−epoch spectral modelling suggests that the overall structure of the torus is likely to remain unchanged. Although, we find tentative evidence for variable line-of-sight column density on time-scales ranging from one day to one week to a few years, suggesting a clumpy circumnuclear material located at subparsec to tens of parsec scales.

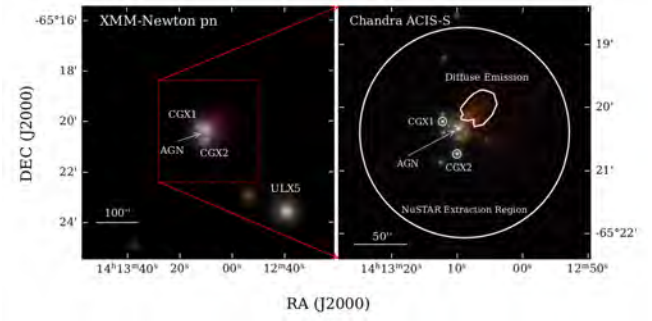

Figure 15: *Left-hand panel*: The 0.5–10 keV *XMM-Newton*/pn image of Circinus in which AGN and off-nuclear contaminating sources CGX1, CGX2, and ULX5 are marked. *Right-hand panel*: The zoom-in view of the central region as seen in the sensitive 0.5–8.0 keV *Chandra* ACIS-S image of 0.5 arcsec angular resolution. The extraction regions of CGX1, CGX2, and extended diffuse emission are marked. The location of the AGN is indicated by an arrow. The large circle represents the NuSTAR extraction region of 100 arcsec radius. Three different colours in both images represent three different energy bands, *i.e.* 0.3–1.5 keV (red), 1.5–2.5 keV (green), and 2.5–8.0 keV (blue).

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This work has been done in collaboration with Prof. Claudio Ricci from Universidad Diego Portales Santiago Chile, Prof. Gulab Dewangan from Inter-University Centre for Astronomy and Astrophysics (IUCAA) Pune India, and Prof. Poshak Gandhi from University of Southampton, UK.

(Abhijit Kayal, Veeresh Singh, N. P. S. Mithun, and Santosh Vadawale)

Intra-night optical variability of peculiar narrow-line Seyfert 1 galaxies with enigmatic jet behaviour

Variability studies of active galactic nuclei are powerful diagnostic tools to understand the physical processes occurring in disc-jet regions that remain unresolved in direct imaging with currently available telescopes. In this work, we report the first attempt to systematically characterize intra-night optical variability (INOV) for a sample of seven apparently radio-quiet narrow-line Seyfert 1 galaxies (NLS1s) that had shown recurring flaring at 37 GHz in the radio observations at Metsahovi radio observatory, indicating the presence of relativistic jets in them. Although, no evidence for relativistic jets are found in radio observations at 1.6 GHz, 5.2 GHz, and 9.0 GHz. Using 1.2m 2.5m telescopes at Mt. Abu observatory and 1.04m, 1.3m telescopes at Nainital we conducted optical monitoring of seven NLS1s in a total of 28 intra-night sessions, each lasting for more than three hours. We find that our sample NLS1s show INOV with a duty cycle of 20% (Figure 16) which is similar to gamma-ray detected NLS1s (DC $\simeq$ 25–30%), that display blazar-like INOV. Thus, it appears that even lower mass (M_{SMBH} $\sim$ 10^6 M$\odot$) NLS1s can maintain blazar-like activities. However, we note that the magnetic re-connection in the magnetosphere of the black hole can also be a viable mechanism to give rise INOV.

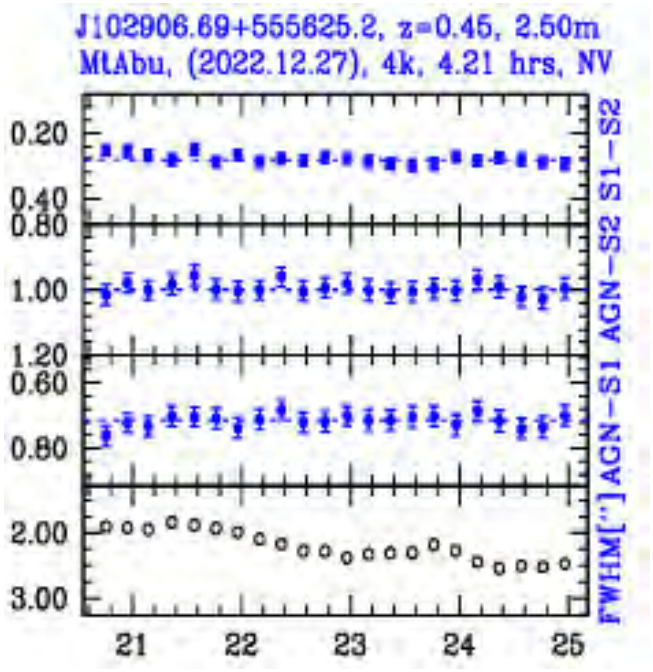

Figure 16: The differential light curves (DLCs) obtained from 2.5m telescope at Mt. Abu for a narrow-line Seyfert 1 galaxy named J102906.69+555625.2 located at redshift 0.45. The $x-$axis depicts time in hours and $y-$axis depicts differential magnitude.

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This work has been done in collaboration with Dr. Marco Berton from European Southern Observatory, Santiago, Chile and Dr. Emilia Jarvela from University of Oklahoma, USA.

(Vineet Ojha and Veeresh Singh)

Prospects of measuring gamma-ray burst polarization with the Daksha mission

Gamma-ray bursts (GRBs) are the most energetic explosions in the universe, resulting in short-lived prompt emissions in X-ray and gamma-rays and later afterglow emission at all wavelengths. The exact emission mechanism of GRBs remains elusive as spectroscopic observations cannot break the degeneracies in theoretical models, and polarisation measurements can provide further input. Daksha is a proposed mission to observe gamma-ray bursts and electromagnetic

counterparts to gravitational wave sources. Its main workhorse, medium energy CZT detectors similar to those used in AstroSat CZTI, can measure polarization in the 100–400 keV energy range. By detailed modeling of the detector geometry and its arrangement in Daksha using Geant4, we carried out simulations to estimate the polarimetric sensitivity of Daksha for GRBs. We show that the minimum detectable polarization (MDP) for GRBs with Daksha is not dependent much on the incident direction within half of the sky fully visible to Daksha, which is attributed to its unique design. For GRBs with 10–1000 keV fluence of 10^{-4} erg cm^{-2}, Daksha will have an MDP of 30%. Thus, Daksha is expected to provide polarization measurements of typically 5 GRBs per year.

doi : https://doi.org/10.1117/1.JATIS.9.4.048002

This work was done in collaboration with Suman Bala, Advait Mehla, Parth Sastry, Sourav Palit, Mehul Vijay Chanda, Divita Saraogi, Gaurav Waratkar, Varun Bhalerao (IITB), Sujay Mate, Shriharsh Tendulkar (TIFR), and Dipankar Bhattacharya (Ashoka University).

(N. P. S. Mithun, C. S. Vaishnava and S. Vadawale)

Discordance of the cosmic radio dipoles with the cosmic microwave background dipole

Investigations of cosmic dipoles in large radio surveys, comprising millions of sources, have yielded much larger amplitudes than the cosmic microwave background (CMB) dipole (Figure 17). The radio dipole directions, though, seem to lie in a narrow sky region around the CMB dipole, which argues for the various dipoles to be related somehow. However, significant differences in their derived peculiar velocities, including that of the CMB, cannot be explained by a peculiar motion of the Solar system, which should necessarily be a single value.

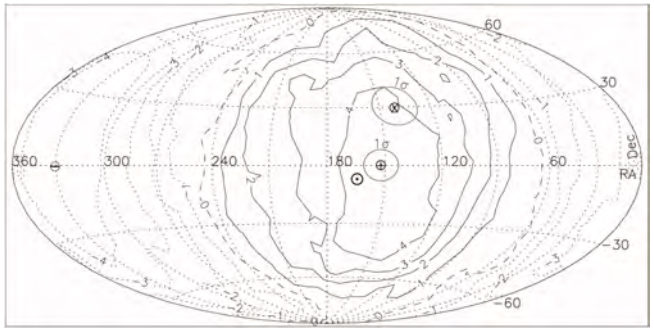

Figure 17: A contour map of the dipole amplitudes (in units of the CMB dipole amplitude) for the NRAO VLA Sky Survey (NVSS), estimated for various directions in the sky. The horizontal and vertical axes denote RA and Dec in degrees. The symbol $\oplus$ indicates the best-fit pole position for the NVSS sample, derived using 3D cos fit to minimize χ^2, while the symbol $\ominus$ indicates the corresponding antipole position. The symbol $\otimes$ indicates another estimate of the dipole position, derived in literature from an alternate method. The gray-colour error ellipses around $\oplus$ and $\otimes$ represent the 1σ (68.3%) confidence limits about the corresponding pole positions. The NVSS dipole amplitude is $\sim$4 times the CMB dipole amplitude.

doi : https://doi.org/10.1093/mnras/stad2161

(Ashok K Singal)

A peculiar motion of Solar system not conversant with different amplitudes of various cosmic dipoles – implications for the cosmological principle

The observed incongruency in dipoles from four large radio surveys, having the same sky coverage and with a similar source number density in sky, seems to result from declination-dependent systematics in the vicinity of the declination limit of some of the surveys. When increasing cuts are applied near the declination limits of these surveys, the systematics get reduced and the inferred dipoles become increasingly congruent. An average position of these four radio dipoles lies within 1.2σ of the CMB dipole position (Figure 18). However, all radio source dipoles gave an amplitude much larger than of the cosmic microwave background (CMB) dipole. This puts in doubt the conventional wisdom that a Solar peculiar motion is responsible for the genesis of these dipoles, including that for the CMB dipole. In that case, all these dipoles being along the same direction indicate a preferred, unique direction, inherently present in the Universe. A scenario like this is not conversant with the cosmological principle, the basis of the modern cosmology, including the standard ΛCDM cosmological model.

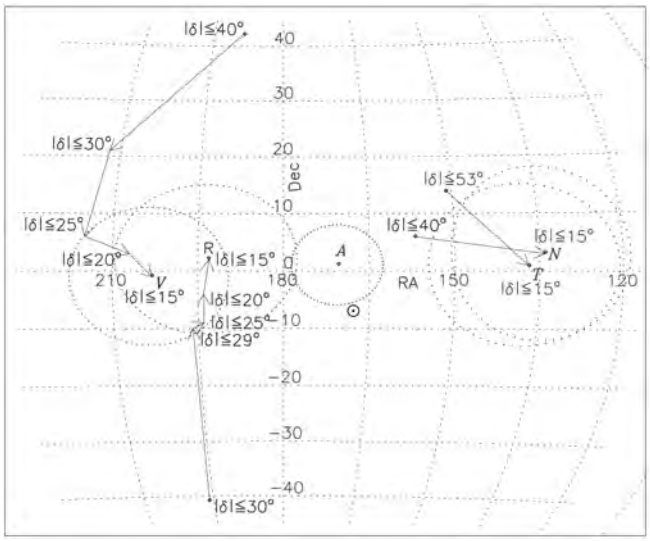

Figure 18: Shifts in the positions of the poles for four radio dipoles along with their final 1σ error ellipses, for various declination cuts. Also shown is the weighted average position (indicated by A) along with its error ellipse, for all the four radio poles. The average dipole position A seems to lie very close to the CMB pole position, at RA$= 168^\circ$, Dec$= -7^\circ$, indicated by $\odot$, which has negligible errors.

doi : https://doi.org/10.1093/mnras/stae414

(Ashok K Singal)

Double Scrambler Design and Implementation in PARAS-2 to achieve $sub-m\ s^{-1}$ RV Precision

Detecting Earth to super Earth-sized planets through Radial Velocity (RV) measurements demands an accuracy of approximately 10 to 30 cm s^{-1}. To achieve such RV precision using high-resolution Doppler spectroscopy, an unparalleled level of long-term instrument stability is required. Among the key technical challenges in enhancing instrument

stability lies the need to stabilize instrument illumination uniformly. We are in the process of developing and implementing an optical double scrambler for the PARAS-2, a fiber-fed cross-dispersed echelle spectrograph works at a resolution of 100,000. The optical design has been carried out in house and the optics and mechanical fabrication is being done by Luma Optics Pvt Ltd, India under Make in India program. This is the first of its kind development within the country. Figure 19 shows the optical ray trace of the double scrambler where we have used two achromatic doublets (rod lenses) separated by a distance of 250 mm, which exchange the far-field and near-field of the input beam and thus scrambling it to a great extent. Figure 20 shows the nicely uniform distribution of light at the exit face of the scrambler. Coupled with octagonal fibers, this scrambler is anticipated to provide significant scrambling gains (SGs) in terms of the long term uniform illumination of the slit position of the spectrograph. Its use will effectively minimize the impact of input illumination variations on the fiber output, thereby enhancing the stability of the spectrograph's instrument profile and thus improving the Doppler measurement precision. Additionally, the output becomes remarkably insensitive to the variations in input pupil, effectively isolating the spectrograph from fluctuations in telescope illumination and changes in atmospheric seeing conditions up to an extent.

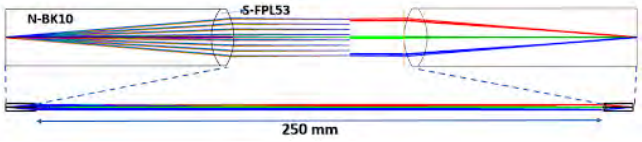

Figure 19: The optical design of the double scrambler.

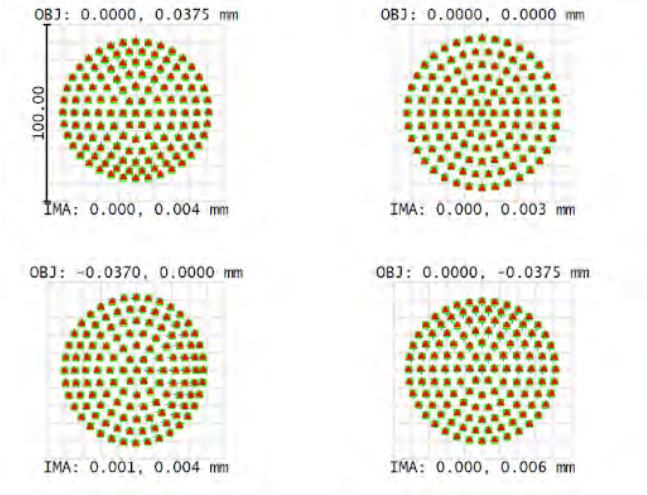

Figure 20: The spot diagram at the exit flat face of the double scrambler, shows the uniform distribution of the light.

(Kapil Kumar Bharadwaj, Neelam JSSV Prasad, Kevikumar Lad, Rishikesh Sharma, Nikitha Jithendran, Ashirbad Nayak, and Abhijit Chakraborty)

Indigenous Development of Atmospheric Dispersion Corrector (ADC) for the PARAS-2 Spectrograph

Astronomical observations made with ground-based telescopes encounter differential atmospheric dispersion, which arises due to the atmosphere's wavelength-dependent refractive index. Radial velocity (RV) measurements, using high resolution spectrographs like PARAS-2 which are used for exoplanet detection, can be adversely affected by uncorrected atmospheric dispersion. The accurate determination of radial velocities is crucial for studying exoplanets, stellar atmospheres, and other astrophysical phenomena. However, the Earth's atmosphere can act as a dispersive medium, causing different wavelengths of light to refract by varying amounts. This dispersion can lead to spectral distortions, impacting the precision of radial velocity measurements. To mitigate this effect, an Atmospheric Dispersion Corrector (ADC, shown in Figure 21) is employed in PARAS-2 which is designed and developed in-house under Make in India (MII) program at Physical Research Laboratory (PRL) Ahmedabad. This is the first of its kind which has been developed and implemented in the country under MII. We have used two sets of counter-rotating prisms. Each set contains two prisms glued together in an inverted position. The ADC is placed inside the cassegrain unit between the collimator and ocuser of the focal reducer (F/8 to F/4). The prisms are manufactured by Luma Optics Pvt Ltd, India. The opto-mechanical holder is designed and fabricated in-house at PRL. Figure 22 shows the spot diagram of the telescope with and without ADC. The ADC is successfully installed and working since May 2023.

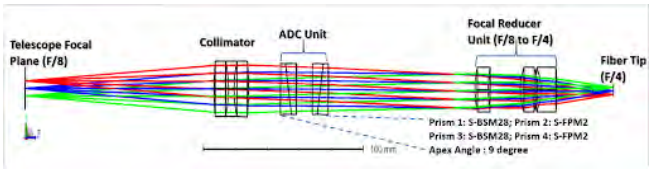

Figure 21: The optical design arrangement of the ADC shows that the ADC unit is positioned within the collimated beam. As shown an achromatic triplet lens is employed to collimate the light beam (F/8) originating from the telescope focal plane. Two sets of inverted prism units are used which rotate in opposite directions to mitigate the dispersion effects from the atmosphere.

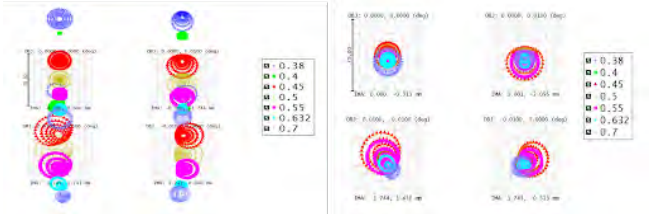

Figure 22: Left: The spot diagram (PSF) of the telescope at the F/4 beam focal plane with no ADC unit. Right: With an ADC unit. The above PSF is for a zenith angle of 50 degree.

(Kapil Kumar Bharadwaj, Neelam JSSV Prasad, Kevikumar Lad, Ashirbad Nayak, Rishikesh Sharma, Nikitha Jithendran, and Abhijit Chakraborty)

Indigenous Development of new Mirror Coating Plant for the 2.5m Telescope

A new mirror coating facility has been developed and installed at the PRL Mount Abu Observatory for the 2.5m telescope (Figure 23), marking a significant milestone as the first of its kind in India under MII (Make in India) initiative. This innovative facility developed in collaboration with Hind High Vacuum Pvt. Ltd (HHV), Bengaluru. It employs thermal evaporation technique, allowing for the upward-facing coating of large-size telescope thin mirrors, reaching up to approximately 2.5m.

This technological advancement ensures superior uniformity in deposition thickness across the mirror's surface, thereby enhancing performance. Furthermore, the process of recoating the mirrors has been streamlined, thanks to dedicated mirror coating removal and cleaning stations specifically designed for the 2.5m telescope mirrors. The facility became operational in October, 2023. This achievement signifies a significant stride towards maintaining the long-term excellence of the telescope mirrors.

Figure 23: Mirror Coating plant for 2.5m diameter mirror installed at PRL Mount Abu Observatory at Gurushikhar, Mount Abu.

(Kevikumar Lad, Kapil Kumar Bharadwaj, Vivek Kumar Mishra, Neelam JSSV Prasad, Ashirbad Nayak, Nafees Ahmed, and Abhijit Chakraborty)

First re-coating of the PRL 2.5m telescope mirrors

The reflectivity of the mirrors of the telescope degrades over time, therefore it is imperative to carry out the coating removal and fresh deposition every year or two. The 2.5m telescope mirrors (primary of dia 2.5m and secondary of dia 0.8m) were recoated (Figure 24) in the last quarter of year 2023 for the first time in the indigenously developed coating facility at PRL observatory, Mount Abu under MII initiatives. The entire activity lasted for five weeks for both the primary and secondary mirrors. Major activities included removal of mirrors from the telescope, removing degraded coating, carrying out mirror cleaning, mirror recoating inside newly installed coating plant and mirror integration to the telescope. Performance parameters such as reflectivity, adhesion of the deposition, deposition thickness, and uniformity indicated the excellent coating quality.

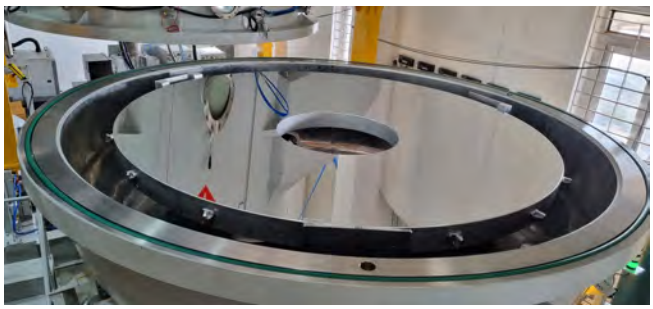

Figure 24: Primary mirror of the PRL 2.5m telescope inside the coating chamber after its first re-coating.

(Kevikumar Lad, Kapil Kumar Bharadwaj, Neelam JSSV Prasad, Vivek Kumar Mishra, Ashirbad Nayak, Nafees Ahmed, Prashanth Kumar Kasarla, Alka Singh, Deekshya Roy Sarkar, Ankita Patel, Bhaveshkumar Mistry, Nikitha Jithendran, and Abhijit Chakraborty)

Development of ProtoPol: A medium resolution echelle Spectro-polarimeter for PRL Telescope

ProtoPol is a medium-resolution echelle spectro-polarimeter initially conceived as the prototype instrument of the currently under development M-FOSC-EP (Mt. Abu Faint Object Spectrograph and Camera-Echelle Polarimeter) instrument – a two-channel multimode instrument which is currently being designed for PRL 2.5m telescope at Mt. Abu, India. M-FOSC-EP would provide capabilities of imaging, low resolution (R $\sim$500–700) spectroscopy and intermediate resolution (R $\sim$15000) spectro-polarimetry in visible wavelengths (382–1000 nm). The designs of M-FOSC-EP and ProtoPol are described in last year annual report. We have successfully completed the development of ProtoPol and commissioned it on the PRL 1.2m and 2.5m telescopes. Here we report on the development and commissioning of ProtoPol.

As a precursor of M-FOSC-EP, ProtoPol was conceived to evaluate the development methodology of M-FOSC-EP with commercially available off-the-shelf components. Similar to M-FOSC-EP, the ProtoPol was designed on the concept of echelle and cross-disperser gratings to record the cross-dispersed spectra in the wavelength range from 390 to 940 nm but with lower resolution (R $\sim$7000-8000). In the ProtoPol design, the telescope focal plane is mapped onto a 150 μm pinhole inside the instrument, which acts as the slit. The incoming beam is then separated into two orthogonal polarized E and O beams by a

polarimeter section consisting of four off-the-shelf achromatic doublet lenses, a Wollaston prism, and an achromatic half waveplate. All these components are selected from the catalogue of the commercial optics manufacturers as per the instrument design. These separated beams are then fed to the spectrometer section consisting of an off-axis parabola as the collimator, an echelle grating and cross-disperser gratings. Two inter-changeable cross-disperser gratings are used for the blue (∼390–600nm) and red (600–940nm) parts of the spectrum. The final dispersed spectra in multiple orders are then collected by an off-the-shelf Canon 200mm focal length camera system, coupled to a commercial ANDOR off-the-shelf 1K × 1K CCD detector system to record the final spectra of E and O-beams in various echelle orders.

ProtoPol is also equipped with a calibration unit to simulate the telescope pupil with the calibration beams from a halogen and spectral lamp (Uranium-Argon) for the spectral calibration and flat-fielding of the recorded spectra. Pupil masks are designed to simulate the 1.2m and 2.5m telescope's pupil within the calibration unit.

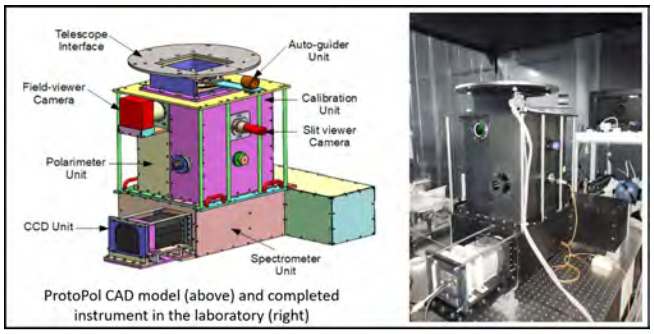

Figure 25: ProtoPol mounted on PRL 1.2m and 2.5m telescopes at Mt. Abu.

ProtoPol can be used on 2.5m and 1.2m PRL telescopes with suitable mechanical interfaces and by replacing pupil masks within the calibration unit. The full-width at half maximum (FWHM) of various emission lines of the Uranium-Argon calibration lamp are determined to be in the range of 3.2–3.5 pixels across various echelle orders. These are consistent with the designed values and provide spectral resolutions of 0.7 to 0.9 angstrom across the spectral range of 390-940 nm. A Glan-Taylor prism is used for the polarization calibration of the on-sky sources. It is mounted on a linear translational stage, which is also equipped with two reflecting fold mirrors. When positioned in the path of the telescope's beam, fold mirror-1 folds the incoming telescope beam toward a field viewer camera with Bessel's V filter. This is to identify the sky field for object selection. The second fold mirror-2 blocks the incoming telescope beam and feeds the beam from the calibration unit into the instrument. The half-wave plate is mounted into an in-house designed stepper motor-driven rotation drive and is positioned at required angles for spectro-polarimetric measurements. The instrument is operated through a fully in-house developed instrument control system and operating software. The detector interface is through the user's interface provided by the camera's manufacturer.

ProtoPol has been fully assembled, integrated and characterized in the laboratory (Figure 25) for its performance and other parameters. It was commissioned on PRL 1.2m telescope in December 2023 and on 2.5m telescope in February 2024 (Figure 26). The design and development methodology of ProtoPol with complete off-the-shelf components offers a cost-effective way to develop spectro-polarimeters with such resolutions for small aperture (2-3m) telescopes around the world with a short development period. Thus, it is expected to be of general interest to global observational astronomy community around the world. At the time of writing this report characterization and science observations of ProtoPol were being conducted on PRL 2.5m telescope.

(Mudit K. Srivastava, Arijit Maiti, Vipin Kumar*, Bhaveshkumar Mistry, Ankita Patel, Vaibhav Dixit#, and Kevikumar Lad). *Current Affiliation: Institute of Physics I, Univ. zu Köln (Germany), # Current Affiliation: Azista Industries, Ahmedabad.)

Characterization setup for infrared photometric calibration for NISP

After characterising ROIC at cryogenic temperature for read noise, dark current and linearity measurement, further tests in laboratory have been carried out to get the expertise in handling the H2RG detector. In this series of experiments, for measuring the response of the detector as a function of wavelength called as relative Quantum Efficiency (QE), a set up was developed in which infrared LEDs of wavelengths 940 nm 1050 nm, 1300 nm, 1600 nm were illuminated on a calibrated InGaAs Photodiode (FGA21-CAL) having a wavelength range of 800–1700 nm with Φ2.0 mm active area.

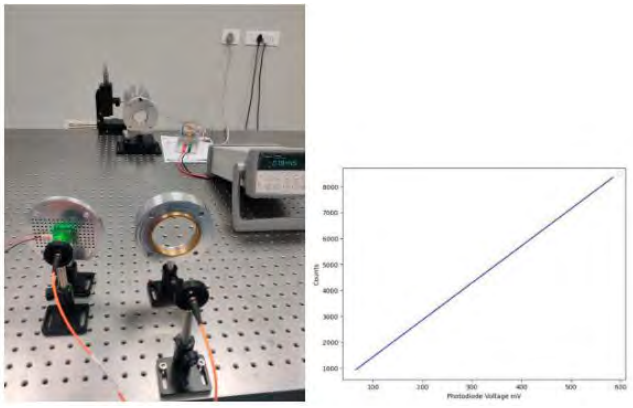

Figure 27: The left panel shows the setup for measuring QE of InGaAs photodiode (FGA 21-CAL) using IR LEDs and collimator. The right panel shows the measured voltage vs counts plot.

The filters Y, J, H, & K, along with a collimator (left panel, Figure 27) were placed in between the IR LED and Photodiode to filter out unwanted wavelengths. The trans-impedance gain calculation was done which came around 0.67 mV for 1000 photons/sec incident on one H2RG pixel (right panel, Figure 27) . This setup can be used for measuring QE of the detector by replacing the Photodiode with H2RG detector.

(Anwesh Mishra, Alka, Deekshya R.S., Prachi Prajapati, Prashanth Kasarla, and NISP team)

HAWAII-2RG detector installation in cryogenic dewar and its dark characterization

Installing the HAWAII-2RG (H2RG) detector in a cryogenic chamber is the most challenging step in the NISP (Near-infrared Imager, Spectrometer, Polarimeter) project, hence to get hands-on experience prior to working with the detector, we have installed the mechanically identical ROIC multiple times with the controller setup. The same procedures were then followed to install the science grade H2RG detector inside the cryogenic vacuum dewar along with its controller board SIDECAR ASIC and a Y band filter (Figure 28). The SIDECAR acquisition board has been mounted outside the dewar and interfaced with SIDECAR using vacuum feedt hrough PCB developed in-house and pre-tested on the ROIC. All the following tests were performed at a stable detector operating temperature of 80 K and pressure 1×10^{-6} mbar inside the NISP Dewar.

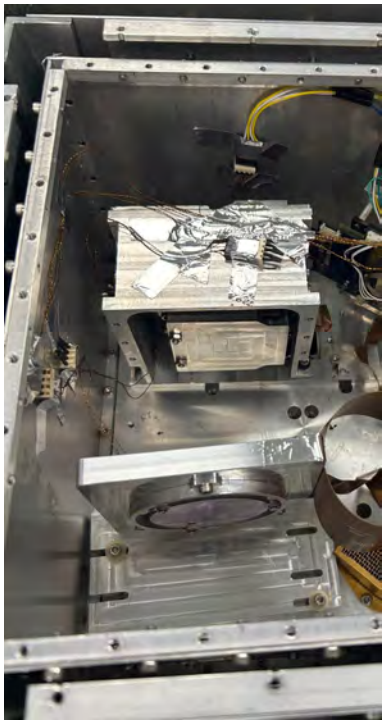

Figure 28: Setup for imaging using H2RG detector with Y Filter.

To verify the detector's performance, we have taken a shadow diagram of a collimated beam from an IR LED having a wavelength of 1050 nm. The beam illuminated the detector through a Y filter and an image was acquired (Figure 29). For the next experiment to measure the dark current in the detector, we removed the Y band filter, and covered the detector with a cold stop. A series of dark frames were taken on a regular basis to the repeatability of data. Setup for dark current measurement is shown in the left panel of Figure 30. The right panel of Figure 30 shows the increasing dark current with increasing exposure time. Three repeat points are shown in different colours, and the points almost exactly overlap, indicating the stable behaviour of the detector and the repeatable nature of the dark current.

Figure 29: The left panel shows the circular obstruction in the collimated beam. The right panel shows the "nisp" mask cutout in the collimated beam.

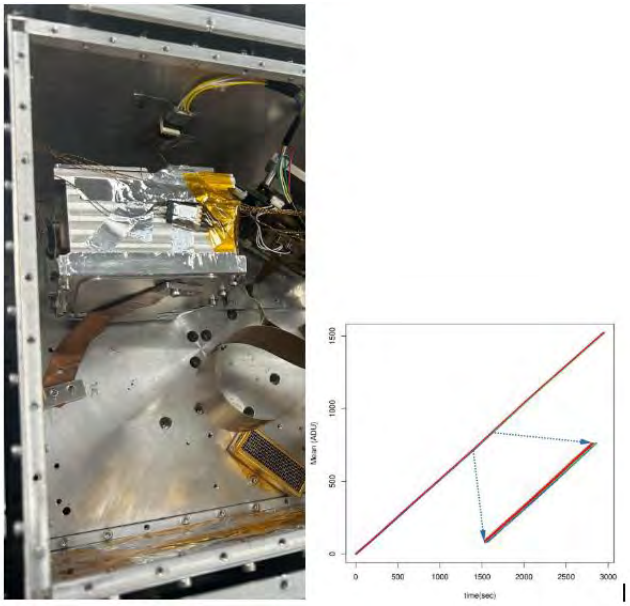

Figure 30: The left panel shows the setup for dark current measurement (Detector covered by a cold stop). The right panel shows the three different repeats of dark current measurement in red, green and blue dots.

(Prashanth Kasarla, Alka, Deekshya, R. S., P. S. Patwal, Hitesh L. Adalaja, Anwesh Mishra, Prachi Prajapati, Sachindra Naik, Shashikiran Ganesh - NISP team)

Solar Physics

Circular ribbon flare triggered from an incomplete fan-spine Configuration

Circular ribbon flares are characterized by circular, semi-circular, or elliptical ribbon brightenings. As the physics of such solar events involves a true 3D magnetic topology, they have been extensively studied in contemporary solar research. The photospheric configurations associated with such complex processes usually involve the so-called anemone-type active regions, which are identified as a compact magnetic region surrounded by magnetic regions of opposite polarity. Such anemone-type active regions usually develop as a compact region of magnetic polarity emerges within an opposite-polarity coronal hole. The magnetic configuration of such anemone-type active regions usually leads to the formation of a 3D null point and associated fan-spine configurations in the corona. The majority of the circular ribbon flares are triggered when a flux rope within the fan dome undergoes upward eruption, leading to magnetic reconnection at the coronal null point.

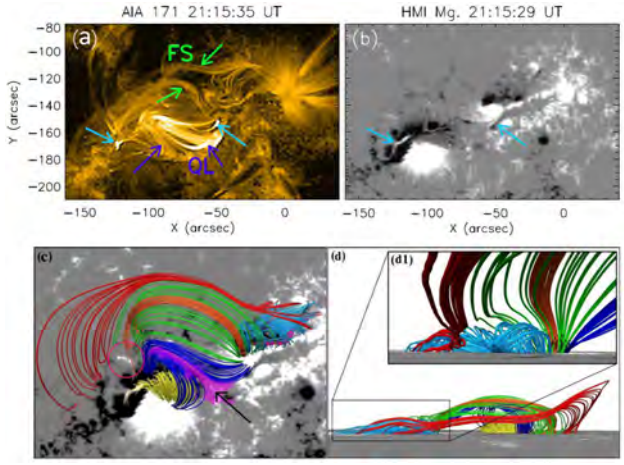

Figure 1 (top). Panel (a): EUV image of the flaring active region NOAA 12297 in the AIA 171 Å channel. The deep-blue arrows indicate the quasi-separatrix layers (QSLs), also marked as QL. The green (also marked FS) indicates a fan-spine configuration which governed the circular ribbon flare. Panel (b): Co-temporal magnetogram. The arrows in sky-blue color in panels (a) and (b) indicate two localized magnetic patches within regions of opposite polarity. Panels (c)-(d): NLFFF-reconstructed coronal magnetic field configuration and distribution of the degree of squashing factor (Q). The multi-colored field lines represent different sets of coronal magnetic fields including a 3D fan-like structure (sky-blue lines) and a flux rope (pink lines). Panel (d) shows all the model lines viewed from the northern boundary, i.e. from the top boundary of panel (c).

In such cases, onset of parallel ribbon is observed within the fan dome which is followed by circular ribbon. However, several recent studies have reported circular ribbon flares where the circular ribbon brightening was observed before the onset of the parallel ribbons. Further, elliptical ribbon flares originating from an elongated fan-spine-like configuration may even lack a null point in their magnetic configuration.

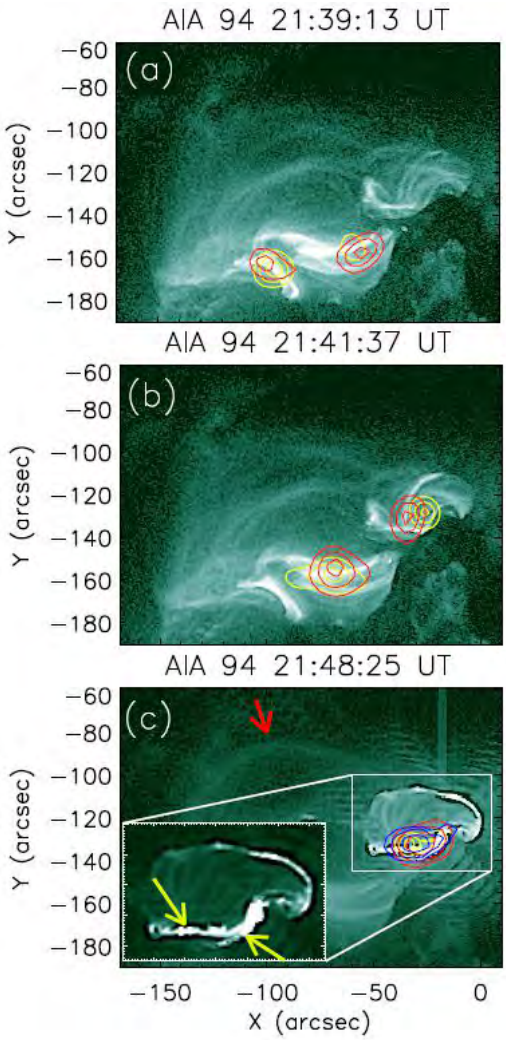

Figure 2 (bottom). Series of AIA 94 Å images of the active region NOAA 12297, showing the evolution of PIXON re-constructed RHESSI X-ray sources before the initiation and during the impulsive phase of the M2.7. The yellow, red and blue contours refer to RHESSI sources in 3-6 keV, 6-12 keV, and 12-25 keV energy ranges. Contour levels are [50, 70, 90].

These recent developments indicate the requirement for further investigation of circular ribbon flares and the associated magnetic configuration to enhance our understanding of the complex solar magnetic configurations and associated transient activities. In order to understand the triggering processes and the complex magnetic topology involved in circular ribbon flares, we carried out a thorough investigation of an M-class circular ribbon flare that originated (indicated by FS in Figure 1(a)) within close proximity of a quasi-separatrix layer (QSL; indicated by QL in Figure

1(a)). The circular ribbon flare occurred from a complex magnetic configuration characterized by negative magnetic patches surrounded by positive-polarity regions on three sides (Figure 1(b)). As the negative polarity patches were not surrounded by positive-polarity regions on all four sides, the corresponding coronal field was devoid of any null points. This led to the formation of an incomplete fan-spine-like configuration that deviated from classical fan-spine configurations in null-point topology (Figure 1(c)-(d)). The presence of the quasi-separatix layer (QSL) was also verified by the nolinear force-free field (NLFFF) modeling. The far end of the spine-like lines terminated very close to one footpoint location of the QSL lines (pink circle, Figure 1(c)). Our analysis suggests that activities at this location led to the activation of a flux rope situated within the fan-like lines and triggering of the circular ribbon flare via perturbation of the overall fan-spine-like structure. Further, we identified RHESSI X-ray sources from the footpoints of the QSL structure (Figure 2(a)-(b)), which suggests that slipping reconnections can also lead to discernible signatures of particle acceleration. As the flare initiated, the X-ray sources moved from the QSL structure to the flaring location (Figure 2(c)).

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This work was done in collaboration with Astrid M. Veronig of Univ. of Graz, Austria.

(Prabir K. Mitra, Bhuwan Joshi)

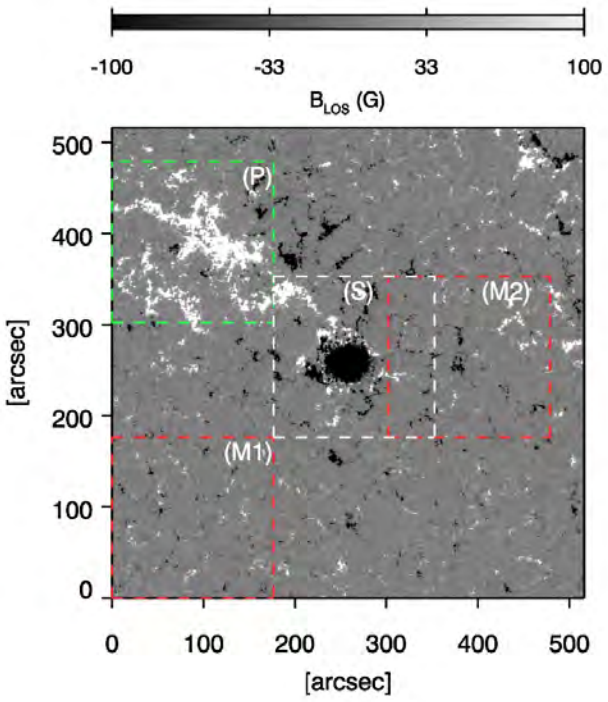

Figure 3. The HMI/SDO line-of-sight magnetic fields of a large active region observed on August 3, 2010 correspond to the start time of the data used in this work. The regions enclosed in red (M1 & M2), white (S) and green (P) colored boxes mark the quiet magnetic network, sunspot and plage sub-regions studied in this work, respectively.

Origin of extreme solar eruptive activity from the active region NOAA 12673

During 2017, when the Sun was moving toward the minimum phase of solar cycle 24, an exceptionally eruptive active region (AR) NOAA 12673 emerged on the Sun during August 28 - September 10. During the highest activity level, the AR turned into a δ-type sunspot region, which manifests the most complex configuration of magnetic fields from the photosphere to the coronal heights. The AR 12673 produced four X-class and 27 M-class flares, along with numerous C-class flares, making it one of the most powerful ARs of solar cycle 24. Notably, it produced the largest flare of solar cycle 24, namely, the X9.3 event on 2017 September 6. We performed a comprehensive analysis involving multi-wavelength imaging and coronal magnetic field modeling to understand the evolution and eruptivity from AR 12673. Our work especially focused on the morphological, spectral, and kinematical evolution of the two X-class flares on 6 September 2017. We explored various large- and small-scale magnetic field structures of the active region which are associated with the triggering and subsequent outbursts during the powerful solar transients.

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(Bhuwan Joshi and Prabir K. Mitra)

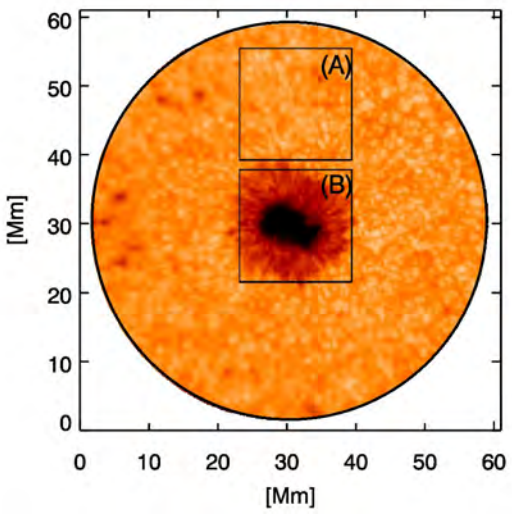

Figure 4. A sample image of continuum intensity showing the field of view of the observations obtained from the IBIS/DST with a sunspot at the center. The black square regions mark the boundaries of sub-regions of a quiet and a sunspot region studied in this work, also denoted by A, and B, respectively.

On the propagation of gravity waves in the lower solar atmosphere in different magnetic configurations

Solar atmospheric heating problem is well known; however, it still remains an enigma to the solar community. Mechanical waves are one of the possible candidates, which can contribute to the heating of the solar atmosphere. Gravity waves in the lower solar atmosphere are generated by turbulent subsurface convection overshooting or penetrating locally into a stably stratified medium. While propagating energy upwards, their characteristic negative phase shift over height is a well-recognized observational signature. Vigeesh et al. (2017) utilizing

the simulations found that gravity waves are scattered/suppressed in the magnetized regions compared to the quiet Sun, indicating that in the presence of background magnetic fields dynamics of gravity waves are affected. We have studied the atmospheric gravity wave dispersion diagrams utilizing intensity observations that cover photospheric to chromospheric heights over different magnetic configurations of quiet-Sun (magnetic network regions), a plage, and a sunspot (c.f. Figure 3) as well as velocity observations within the photospheric layer over a quiet and a sunspot region (c.f. Figure 4).

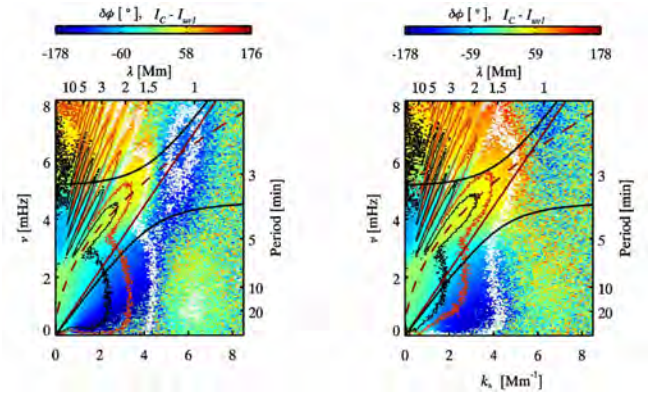

Figure 5. Cross-spectral phase difference, $\delta\phi$ (k_h, ν), diagrams of the quiet-region M1 (left panel) and the sunspot region S (right panel), respectively, constructed from Ic - Iuv1 pair of photospheric continuum intensity from HMI/SDO and UV 1700 Å channel of AIA/SDO, which corresponds to 20 - 360 km above z = 0 in the solar atmosphere. The solid black lines separate vertically propagating waves ($k_z^2 > 0$) from the evanescent ones ($k_z^2 < 0$) at upper height. The dashed red line is the f-mode dispersion curve and the solid red line is the Lamb mode. The overplotted black, red and white contours represent the coherence at 0.5, 0.3 and 0.1 levels, respectively.

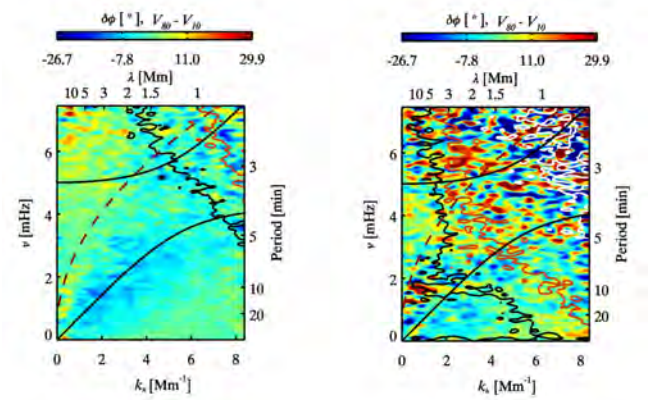

Figure 6. Cross-spectral phase difference, $\delta\phi$ (k_h, ν), diagrams of quiet-region A (left panel) and sunspot region B (right panel), respectively, constructed from V80 - V10 velocity pair of photospheric Fe I line observations obtained from the IBIS instrument, which corresponds to different heights within 16 - 302 km above z = 0 in the solar atmosphere.

The intensity observations of the photosphere i.e. continuum intensity (Ic) and lower chromospheric intensity i.e. 1700 and 1600 Å observations have been obtained from the Helioseismic and Magnetic Imager (HMI) and Atmospheric Imaging Assembly (AIA) instruments, respectively, on board the Solar Dynamics Observatory (SDO) spacecraft. Two height velocities within the photosphere have been estimated from the Fe I 6173 Å line scan observations obtained from the Interferometric Bidimensional Spectropolarimeter (IBIS) installed at the Dunn Solar Telescope (DST) at Sacramento Peak, New Mexico, USA. In order to investigate the propagation characteristics, we construct two height intensity-intensity and velocity-velocity cross-spectra and study phase and coherence signals in the wavenumber-frequency dispersion diagrams and their association with background magnetic fields. We observe signatures of association between magnetic fields and much reduced coherence and phase shifts over height from intensity-intensity (c.f. Figure 5) and velocity-velocity phase and coherence diagrams (c.f. Figure 6), both indicating suppression/scattering of gravity waves by the magnetic fields. Our results provide observational evidence to the earlier numerical simulations, which indicate that gravity waves are suppressed or scattered and reflected back into the lower solar atmosphere in the presence of magnetic fields.

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This work has been done in collaboration with S.P. Rajaguru of Indian Institute of Astrophysics, Bengaluru.

(Hirdesh Kumar, and Brajesh Kumar)

Rotation of a Stealth CME on 2012 October 5 Observed in the Inner Heliosphere

Coronal mass ejections (CMEs) are subject to changes in their direction of propagation, tilt, and other properties. This is because CMEs interact with the ambient solar wind and other large-scale magnetic field structures. We analyzed the observations of the 2012 October 5 stealth CME using coronagraphic and heliospheric images. We find clear evidence of a continuous rotation of the CME, i.e., an increase in the tilt angle, estimated using the graduated cylindrical shell (GCS) reconstruction at different heliocentric distances, up to 58 $R_\odot$.

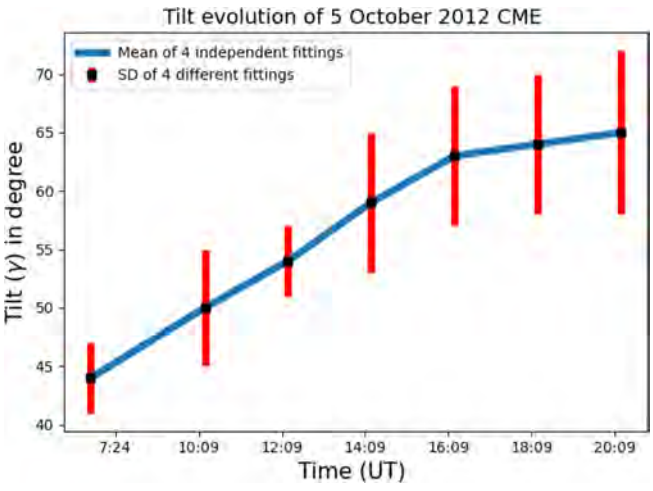

Figure 7. Time evolution of tilt of the CME of 2012 October 5 in COR2 last frame and in the HI FOV obtained from the GCS fitting. The error bars are incorporated based on four independent fittings.

We find a further increase in the tilt at L1 estimated from the toroidal and cylindrical flux rope fitting on the in situ observations of

interplanetary magnetic field (IMF) and solar wind parameters. This study highlights the importance of observations of the Heliospheric Imager (HI), on board the Solar Terrestrial Relations Observatory (STEREO). The 2012 October 5 CME did not leave any low coronal signatures on the disk, making it difficult for forecasters to assess its impact on Earth on the basis of the near-Sun observations alone. The CME propagated at a moderate speed of 600 km s^{-1} near the Sun. However, it experienced a continuous increase in its tilt during its propagation from the Sun to the Earth. This led to a prolonged southward component of the flux rope, which was responsible for its enhanced geoeffectiveness. Our results further highlight the challenges in space weather forecasting of such stealthy CMEs. In this context, HI observations prove to be crucial and bridge the gap between the near-Sun and near-Earth observation, thereby providing an improved understanding of CME propagation in the heliosphere.

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This work has been done in collaboration with Dinesha V. Hegde and Nikolai V. Pogorelov of the University of Huntsville, Alabama, Nat Gopalswamy and Seiji Yashiro of GSFC, NASA

(Sandeep Kumar, Nandita Srivastava)

Source region of 3-min waves observed in coronal fan loops rooted in sunspot umbra

Coronal fan loops originating from sunspot umbrae display a 3-min period propagating slow magnetoacoustic waves in the corona. However, their origin in the lower atmosphere is still unclear. We conducted a comprehensive study of the sunspot using simultaneous images from AIA 193 Å, 171 Å, 304 Å, 1700 Å, IRIS 2796 Å, and HMI continuum and Dopplergram. These images provide insights into different layers of the solar atmosphere, revealing coronal temperatures of 1.6 MK and 0.7 MK, transition region temperature of 50,000 K, chromospheric temperature of 10,000 K, temperature minimum region of 5000 K, and photospheric temperature of 6000 K, respectively. In Figure 8, we present the sunspot observed from these passbands as labeled. It is evident from the images that the appearance of the sunspot varies significantly across different atmospheric layers, which emphasizes the complexities involved in their dynamics. We identified several fan loops rooted in sunspot umbra and traced their foot-points by identifying their locations at various atmospheric heights, from the corona down to the photosphere (see Figure 8). This tracing also provided us the first indirect observational evidence of area expansion of the loop from photosphere to corona. During our investigation, we found presence of 3-min oscillations at the foot-points of all the loops and at all atmospheric levels (see Figure 9). To further trace the origin of these waves, we leveraged their amplitude modulation characteristics as they propagated through the solar atmosphere. Our findings revealed multiple amplitude modulation periods in the range of 9-14, 20-24, and 30-40 min for these 3-min waves at all heights. We also explored any connection between 3-min and 5-min oscillations observed at the photospheric foot-points of these loops and found them to be weakly coupled. Based on our findings, we interpreted that the 3-min slow magnetoacoustic waves propagating in coronal fan loops are driven by the 3-min oscillations observed at the photospheric foot-points of these fan loops in the umbral region. These results offer clear evidence of magnetic coupling within the solar atmosphere, demonstrated through wave propagation from the photosphere to the corona via the chromosphere and transition region. Such findings can provide valuable insights for modeling of wave propagation in the solar atmosphere.

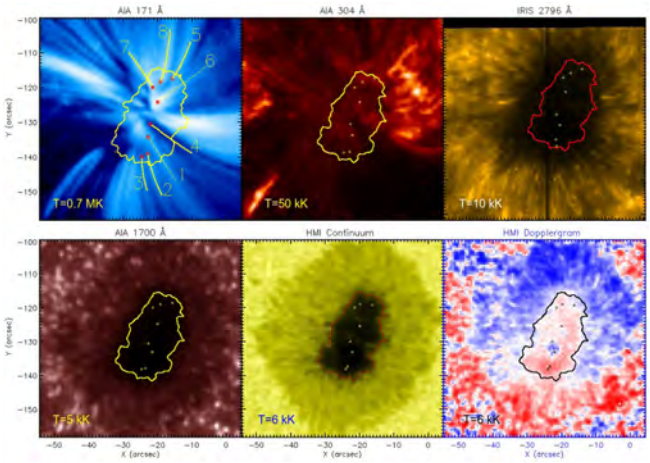

Figure 8. Images of the sunspot observed from different passbands sensitive to different temperatures as labeled. The fan loop system is clearly visible in the AIA 171Å image. Identified loop foot-points in the corona and lower atmosphere are marked with asterisks and small circles respectively. Additionally, for visualization purposes, we have drawn the traced coronal loops in the AIA 171Å image. Contours on the images represent the umbra-penumbra boundary.

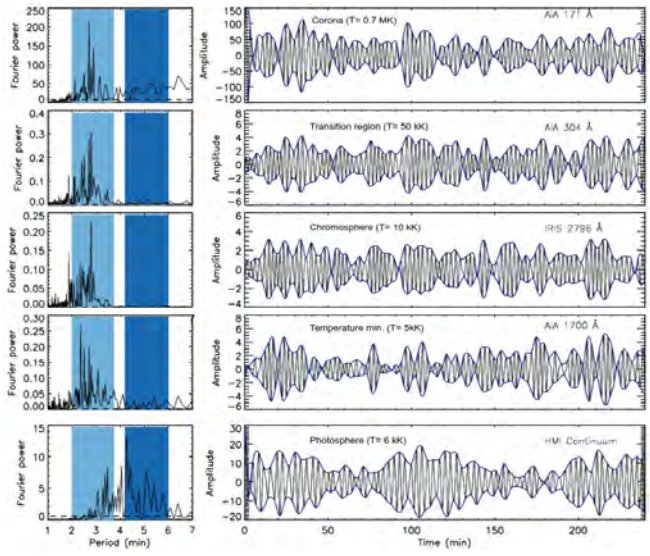

Figure 9. Left panels: FFT power spectrum of original light curves obtained at each atmospheric height of loop 6 as labeled. Shaded regions in light and dark blue color denote the 3-min and 5-min period band respectively. Horizontal and vertical dashed lines represent 95% significance level, and the dominant peak in the 3- and 5-min period bands respectively. Right-hand panels: 3-min filtered light curves with overplotted blue lines show amplitude modulation envelopes.

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(Ananya Rawat and Girjesh Gupta)

Classification of circular polarization Stokes profiles in sunspots using k-means clustering

The magnetic and velocity fields in sunspots are highly structured on small spatial scales which are encoded in the Stokes profiles. The Stokes profiles are in turn, derived from a sequence of polarization modulations on the incoming light that are imaged using an analyser-detector combination. Our aim is to identify Stokes profiles in a sunspot which exhibit spectral characteristics that deviate from those associated with the Evershed flow and their corresponding spatial distribution. To that end, we employ the k-means clustering routine to classify Stokes V spectra in the penumbra of a regular, unipolar sunspot, that also comprises a granular and a filamentary light bridge. We find that 75% of the penumbral region, corresponding to about 93500 pixels, is dominated by profiles comprising two, nearly anti-symmetric lobes, while 21% of the area is occupied by three-lobed profiles that are associated with the Evershed flow returning to the solar photosphere.

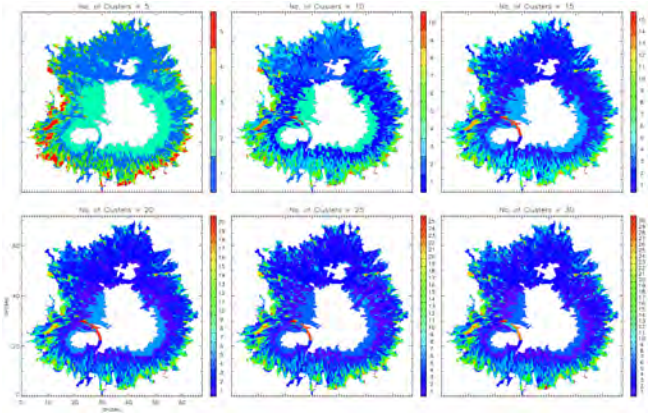

Figure 10. Inter-cluster variation for select number of clusters. The numbers in the legend are in ascending order from the most populous (violet) cluster to the most scarce (red) cluster.

The remaining 4% of the penumbral area is dominated by four groups/families of profiles - Group 1: three-lobed profiles in which both the rest and strong downflowing (sometimes supersonic) component have the same polarity as the host sunspot and seen exclusively in the filamentary light bridge. Group 2: single, red-lobed profiles occupying an area of about 2% located at the outer penumbra in discrete patches that possibly signify the downflowing leg of an Ω-loop. Group 3: three-lobed or highly asymmetric profiles, in which the rest component and the strong downflowing component have an opposite polarity as the sunspot. These occupy about 1.4% of the penumbra's area and are seen in conspicuous, elongated structures or isolated patches in the outer penumbra and at the penumbra-quiet Sun boundary. Group 4: three lobed-profiles, in which the rest component has the same polarity as the sunspot and a weaker, upflowing component with a polarity opposite that of the sunspot. These profiles are located close to the entrance of the filamentary light bridge and are found in only 0.12% of the penumbral area. These minority groups of profiles could be related to dynamic phenomena that could also affect the overlying chromosphere. The simplicity and speed of k-means can be utilized to identify such anomalous profiles in larger data sets to ascertain their temporal evolution and the physical processes responsible for these inhomogeneities.

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(Louis, Rohan E.; Mathew, Shibu K.; Bayanna, Raja)

Hall effect on the magnetic reconnections during the evolution of a three-dimensional magnetic flux rope

Magnetic flux ropes (MFRs) play a crucial role in eruptive events such as the Coronal Mass Ejections (CMEs) in the solar atmosphere. However, their formation and subsequent evolution remains to be better understood. In this study, the formation and evolution of a three-dimensional (3D) magnetic flux rope (MFR) is compared within the framework of magnetohydrodynamics (MHD) and Hall MHD (HMHD) simulations. The rationale behind using the two frameworks comes from the possibility of arriving at a differentiator that could help to gain new insights into the dynamics of 3D MFRs. A 3D bipolar sheared arcade is employed to initiate the simulations. The simulated dynamics reveals generation of 3D magnetic null points (points where all components of magnetic field are zero) due to reconnection between field lines of the initially chosen arcade configuration. These null points are further seen to host reconnection, leading to generation of a 3D MFR. A comprehensive comparison of the two simulations shows that the reconnections forming the MFR are identical, i.e., insensitive to the Hall MHD. However, their later evolution differs qualitatively as well as quantitatively. Notably, post-reconnection arcades develop faster in HMHD and field lines are seen to get twisted near null points only in HMHD (c.f. Figure 11). Importantly, we find that this twisting of field lines near the reconnection sites (magnetic nulls) can explain the swirling motion of plasma during certain prominence eruption events.

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This work was done in collaboration with Dr. Sanjay Kumar of Patna University, India.

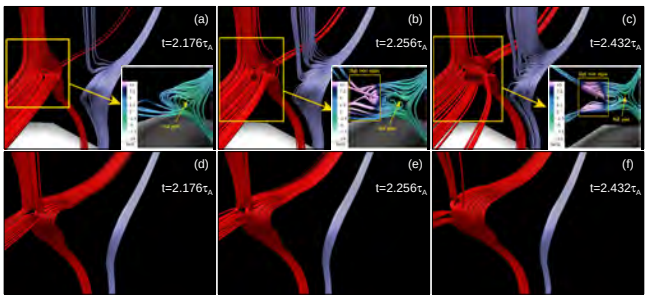

Figure 11. Panels (a)-(c) and (d)-(f) depict the snapshots from the HMHD simulation and MHD simulations. The red field lines form a twisted magnetic structure during HMHD which is not present in MHD. The inset images show the presence of a 3D null point and development of twist.

(Kamlesh Bora, Satyam Agarwal, and Ramit Bhattacharyya)

Magnetohydrodynamics simulation of magnetic flux rope formation in a quadrupolar magnetic field configuration

The role of Magnetic flux ropes (MFRs) in eruptive events such as the Coronal Mass Ejections (CMEs) is well recognized but the mechanism of their formation is not well understood. Since magnetic configurations on the Sun can be quite complex, and so far, MFR formation has been explored mostly in bipolar regions (consisting of one positive and one negative polarity), we have carried out the MHD simulations to investigate MFR formation in a quadrupolar configuration. The term quadrupolar refers to two positive and two negative magnetic polarities in the system. The initial magnetic field has been constructed to be non-force-free, by modifying a three-dimensional linear force-free field, having field line geometry similar to the observed coronal loops. This initial configuration contains an X-type neutral line at the center, which plays a significant role in governing the dynamical evolution. We find that repetitive reconnections lead to the formation of four MFRs and with time (c.f. Figure 12), these MFRs move towards the X-type line and reconnect with each other, leading to the generation of complex structures around the neutral line. The MFRs were seen to rise non-uniformly, where the aforementioned complex structures rise faster than the rest of the rope. Importantly, our simulations indicate that the pre-existing X-type neutral points in magnetic configurations may play a crucial role in the evolution of the MFRs and may lead to the observed X-shaped brightenings in the coronal quadrupolar configurations.

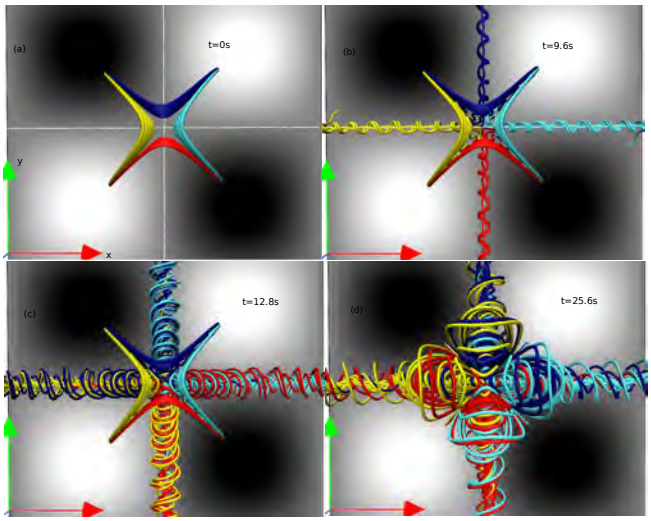

Figure 12. The zoomed-in top view of the MHD evolution of the magnetic field lines near the X-type neutral line inside the computational domain. Reconnections of the flux ropes at the X-type neutral line are evident leading to the formation of complex magnetic structures.

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This work was done in collaboration with Dr. Sanjay Kumar (Patna University, India), Avijeet Prasad (University of Oslo, Norway), and Sushree S Nayak (University of Alabama, Huntsville, USA).

(Satyam Agarwal, and Ramit Bhattacharyya)

Study of Reconnection Dynamics and Plasma Relaxation in MHD Simulation of a Solar Flare

Solar flares are manifestations of magnetic reconnection, where the dissipated magnetic energy is released in the form of heat and acceleration of charged particles. Consequently, the magnetofluid is expected to relax. Toward such exploration, a three dimensional MHD simulation for a GOES M1.3 is carried out. The start and end time of flares were 15:18 UT and 15:53 UT, respectively. Consequently, the photospheric vector magnetogram at 15:12 UT is employed to extrapolate the magnetic field by using a non-force-free field model. The extrapolation identifies a hyperbolic flux tube (HFT), cospatial with the brightenings observed in 1600 Å and 304 Å channels of SDO/AIA.

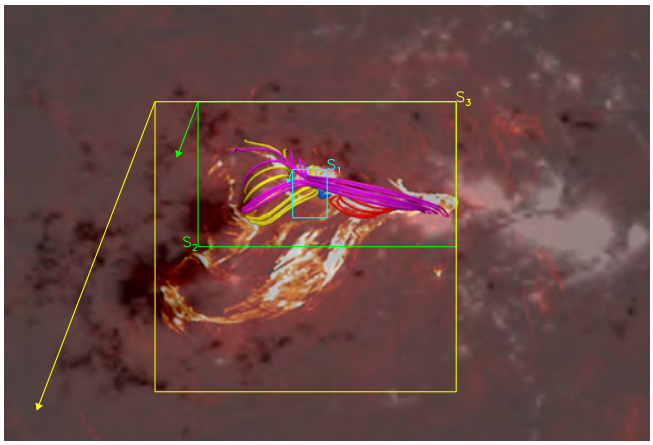

Figure 13. A visual representation of subvolumes S1, S2, and S3 . The HFT configuration, overlaid with the vertical component of magnetic field and observation of the flaring event in 304Å channel of SDO/AIA at 15:35:52 UT, is shown.

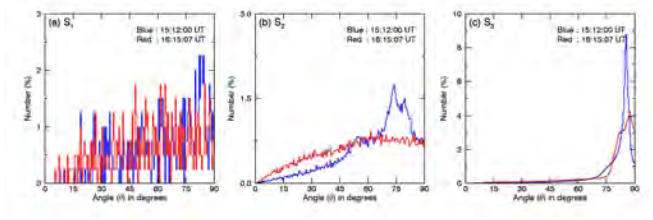

Figure 14. The distribution of angles between current density (J) and magnetic field (B) in subvolumes S1, S2, and S3 at the beginning (blue) and end (red) of simulation, where $J \times B = 0$ identifies a force-free state.

Subsequently, the EULAG-MHD numerical model is employed to initiate the MHD simulation with extrapolated field as the initial condition. Subsequently, the magnetofluid dynamics in the simulation is explored and it is found that the overall simulation shows signatures of relaxation. For a detailed analysis, three distinct subvolumes are considered (c.f. Figure 13) and magnetic field line dynamics along with time evolution of physically relevant quantities like magnetic energy, current density, twist, and gradients in magnetic field are analyzed. In the terminal state, none of the subvolumes is seen to reach a force-free state (c.f. Figure 14), thus remaining in nonequilibrium, suggesting the possibility of further relaxation. It is concluded that the extent of relaxation depends on the efficacy and duration of

reconnection, and hence on the energetics and time span of the flare.

doi : https://doi.org/10.1007/s11207-024-02255-5

This work has been done in collaboration with Shangbin Yang (Key Laboratory of Solar Activity, National Astronomical Observatories, Beijing, China).

(Satyam Agarwal, and Ramit Bhattacharyya)

Solar Hysteresis Pattern and Spectral Components in TEC Time Series (GPS and TIE-GCM) of the Quadrilaterally Coupled Geomagnetic Conjugate Low-latitude Stations

The current study is a first-of-its-kind in that it compares the Total Electron Content (TEC) of the solar cycle-24 from the Global Positioning System (GPS) and Thermosphere -Ionosphere-Electrodynamics General Circulation Model (TIE-GCM) over the geomagnetically conjugate low-latitude stations with the particular scenario of lower atmospheric conditions over land-locked (Varanasi (25.31°N; 82.97°E) and LHAZ (29.65°N; 91.10°E)) and sea-locked (DGAR (7.27°S; 72.37°E) and COCO Island (12.18°S; 96.83°E)) locations.

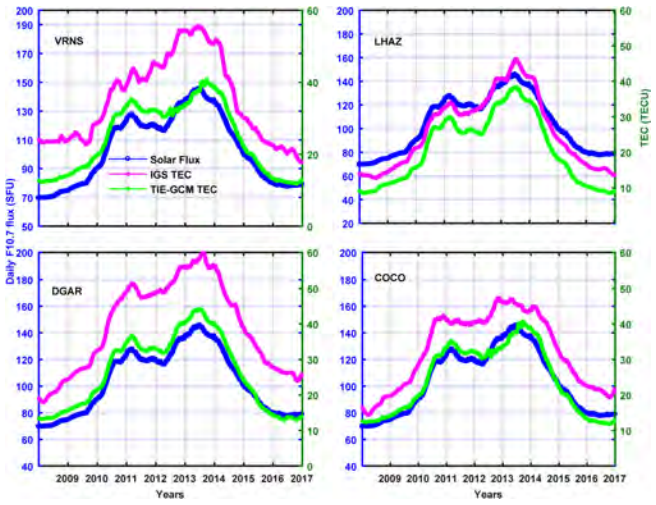

Figure 15. The solar cycle variation of the 365-day centered running mean of F10.7 flux indices (blue curve), GPS TEC (pink curve), and TIE-GCM TEC (green curve) is shown. The left ordinate gives the scale of F10.7 flux, and the right ordinate gives the scale of TEC.

The solar cycle variation in TEC is identified by two distinct maxima and the hsteresis between the ascending and descending phases (Figure 15). The solar cycle trends are modulated by the equatorial ionization anomaly as well as longitudinal biases. The Lomb-Scargle periodogram shows that the improved TIE-GCM version 2.0, which incorporates variable eddy diffusion to provide an accurate simulation of seasonal variability, is largely successful in simulating semi-annual and annual oscillations but still needs to resolve the seasonal anomaly feature, particularly in the case of southern low latitude stations (Figure 16). Terannual (120-day) and 1.4-year (500-day) periodicities in the TEC time series are observed only at EIA region stations, not at the off-crest location LHAZ, and are most likely caused by $\mathrm{E} \times \mathrm{B}$ drift. The wavelet coherence analysis reveals that the Quasi Biannual Oscillations (QBO) in the TEC time series (597-, 773-, and 930-day) have a strong physical affinity with the QBO oscillation of F10.7 flux. Results indicate that both solar activity and equatorial electrodynamics significantly influence the QBO oscillation in the TEC.

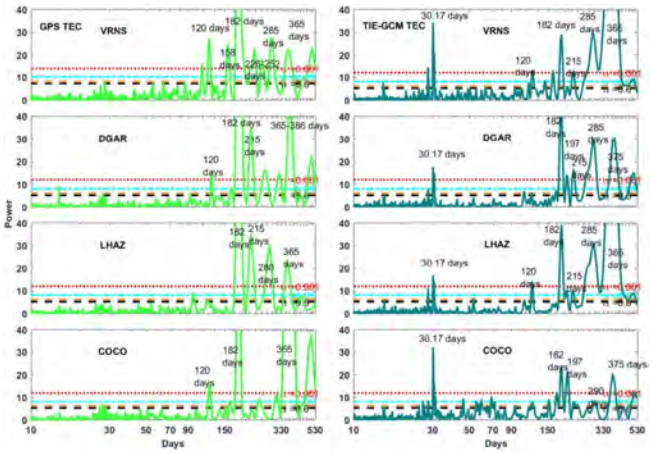

Figure 16. The periodicities inherent to the daily noontime maximum GPS TEC (left panel) and TIE-GCM TEC (right panel) data on applying the Lomb-Scargle periodogram technique are shown.

doi : https://doi.org/10.1029/2023JA031428

(S. S. Rao, D. Chakrabarty, and Nandita Srivastava)

Observations of Geomagnetic Crochet at High-Latitudes due to X1.5 class Solar Flare on 3 July 2021

Using IMAGE magnetometer network data, we investigated the geomagnetic signatures of the X1.5 solar flare that occurred on July 3, 2021, in the newly emerged NOAA AR12838 at the limb (24°N, 88°W). The X1.5 flare occurred in a unique solar active region that initially appeared as a bi-polar intense magnetic region on the west limb, later identified as beta-type AR (Figure 17).

In order to study the solar flare-induced geomagnetic variations, the variation of the northern (X), eastern (Y), and vertical (Z) components of the geomagnetic field at high latitudes (50° - 78°N) in the longitudinal grid of 11° - 26°E during the X1.5 solar flare of July 3, 2021, is presented. The findings of the work are as follows: (i) observations of cusp crochet of short duration (10-15 min) and smaller magnitude (8-40 nT) at ≈ 78°N (Figure 18); (ii) observation of sub-solar and a newly defined geomagnetic crochet feature at latitude belt 50° - 70° N (not shown here). These geomagnetic crochet observations reveal the following characteristics: (i) an enhancement in geomagnetic field components during flare peak time without spike; (ii) a positive or negative spike in geomagnetic field components, particularly an explicit and coherent appearance in the Y component at equatorward stations; (iii) post-spike enhancement in magnetic field components embodied with multiple peaks at poleward stations and smoothed variation at equatorward stations; (iv) latitudinally, at first, the X component responded to flare-induced current at the cusp

region; thereafter, Z started to respond from 77°N downward, and finally, Y started to respond from the south of 71°N; (v) the observed latitudinal variation of crochet strength, shape, and time evolution is related to the latitudinal distribution and time evolution of the ionospheric equivalent current (IEC), and (vi) the different components have different sensitivities to the solar flare effect.

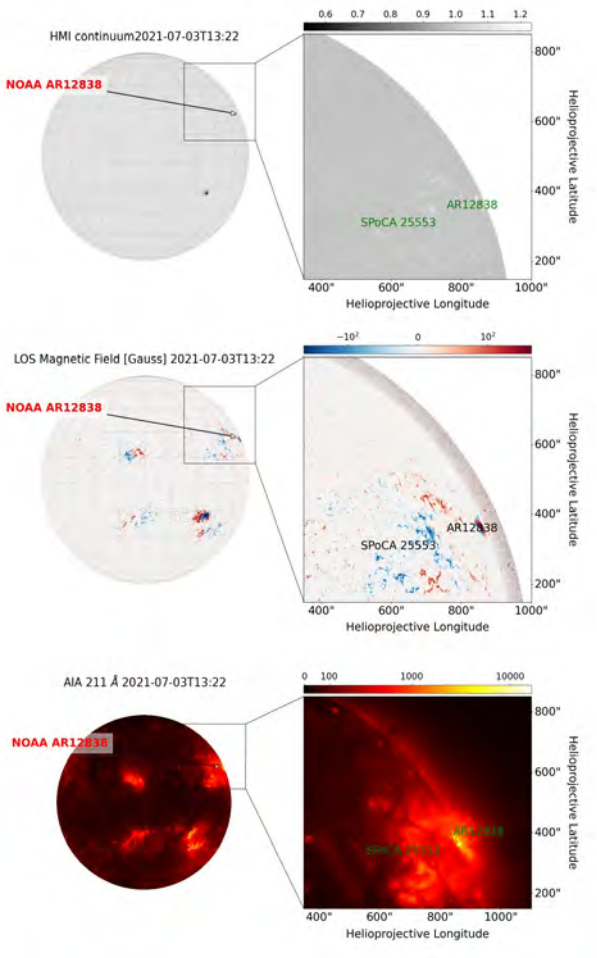

Figure 17. Top panel shows the location of the AR on the west limb in the HMI continuum image on 3 July 2021. The middle panel shows the HMI LOS magnetogram with newly emerging AR 12838. The bottom panel shows the AIA 211Å images.

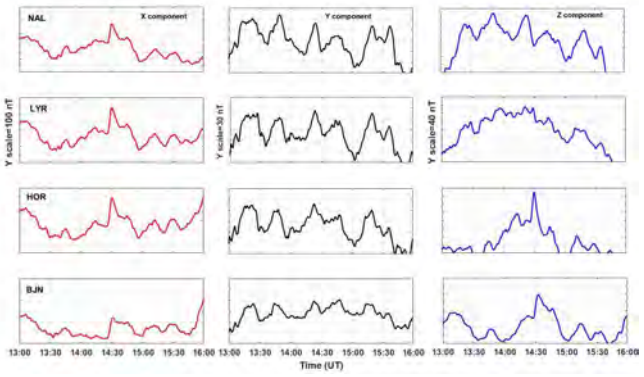

Figure 18. Geomagnetic Observations in the Latitudinal Belt $74^\circ - 79^\circ$

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This work has been done in collaboration with Dr. Monti Chakraborty of Tripura University, Agartala.

(S. S. Rao, Nandita Srivastava, Monti Chakraborty, Sandeep Kumar, D. Chakrabarty)

Space and Atmospheric Sciences

Aerosols are heating up the Himalayan climate

The impact of aerosols, in particular the absorbing aerosols, in the Himayalan region is important for climate.

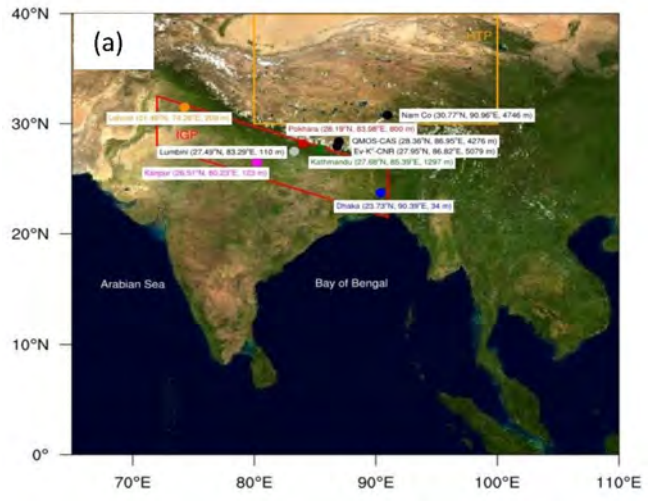

Figure 1: (a) Details of the locations of observation sites in the Indo-Gangetic Plain (IGP) and the Himalayan foothills in South Asia: The latitude, longitude, and elevation (in meters above sea level, m asl) of each location are given. Four observation sites - Lahore (Pakistan), Kanpur (India), Lumbini (Nepal) and Dhaka (Bangladesh) - are located along a northwest-southeast transect of the IGP, while three sites (Lumbini, Pokhara and Kathmandu in Nepal) are located at increasing altitudes from the northern edge of the IGP to the Himalayan foothills.

We have closely examined ground-based high-quality observations of aerosol characteristics including radiative forcing from several locations in the Indo-Gangetic Plain (IGP), the Himalayan foothills and the Tibetan Plateau (Figure 1(a)), relatively less studied regions with several sensitive ecosystems of global importance, as well as highly vulnerable large populations. This is a first-time analysis of its kind, including ground-based observations, satellite data, and model simulations. The aerosol optical depth (AOD) is $>$ 0.30 and single scattering albedo (SSA) is 0.90 throughout the year over this region (Figure 1(b) and 1(c)). The aerosol radiative forcing in the atmosphere over the IGP and the Himalayan foothills is higher than 20 Wm^{-2} during the year. The analysis reveals that the aerosol radiative forcing efficiency (ARFE) in the atmosphere is clearly high over the IGP and the Himalayan foothills (80-135 Wm^{-2} per unit AOD), with values being greater at higher elevations (Figure 1(d), 1(e) and 1(f)). The mean ARFE is 2-4 times higher here than that over the other polluted sites in South and East Asia, owing to a higher AOD and aerosol absorption (i.e., lower SSA). Further, observed annual mean aerosol-induced atmospheric heating rates (0.5-0.8 K/day) (Figure 1(e)), which are significantly higher than the previously reported values for the region, imply that the aerosols alone could account for more than 50% of the total warming (aerosols + greenhouse gases) of the lower atmosphere and surface over this region. We have demonstrated that the current state-of-the-art models used in climate assessments (e.g., the U.K. Earth System Model (UKESM1)) significantly underestimate the aerosol-induced heating, efficiency and warming over the Hindu Kush Himalaya Tibetan Plateau (HKHTP) region, indicating a need for a more realistic representation of aerosol properties, especially of black carbon and other aerosols (Figure 2). The significant, regionally coherent aerosol-induced warming that we observe in the high altitudes of the region, is an important factor contributing to increasing air temperature, observed accelerated retreat of the glaciers, and changes in the hydrological cycle and precipitation patterns over this region. Thus, aerosols are heating up the Himalayan climate, and will remain a key factor driving climate change over the region.

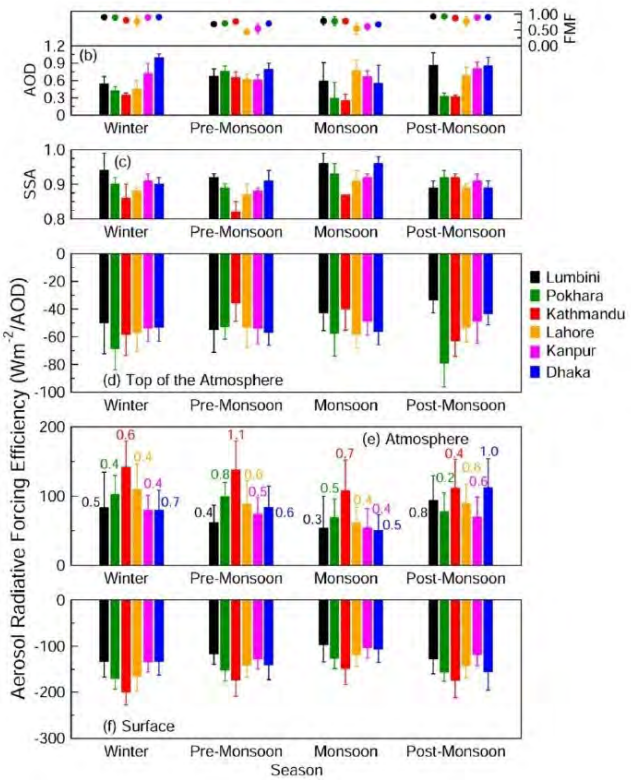

Figure 1: (b) Seasonal mean aerosol optical depth (AOD), fine mode fraction (FMF) and (c) single scattering albedo (SSA) corresponding to a wavelength of 0.50 μm. Vertical bars indicate 1σ (standard deviation) from the mean. Seasons are defined as winter: Dec-Feb; pre-monsoon: March-May; monsoon: June-September; and post-monsoon: October-November. Aerosol radiative forcing efficiency (Wm^{-2} per unit AOD) (d) at the top of the atmosphere, (e) in the atmosphere and (f) at the surface. Vertical bars represent 1σ (standard deviation) from the mean. The seasonal mean atmospheric solar heating rate (Kelvin day^{-1}) estimated using the aerosol radiative forcing (Wm^{-2}) in the atmosphere corresponding to each location for each season is given as values above the bars in (e).

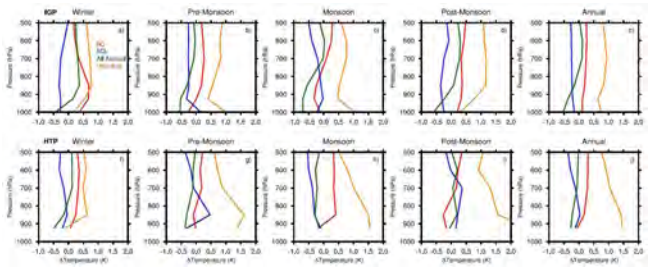

Figure 2: The change in temperature (K) due to aerosols and greenhouse gases in the lower atmosphere over the IGP and the HTP simulated by UKESM1 (the U.K. Earth System Model). The temperature change is calculated as the difference in temperature between 2014 and 1850. Temperature changes are shown due to BC, SO_2, and all aerosols, along with historical values (which include the impacts of actual transient emissions of aerosols and greenhouse gases (GHGs) and natural variabilities), on a seasonal scale over the IGP (a-d) and over the HTP (f-i), and annually for the IGP (e) and for the HTP (j).

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This work was done in collaboration with Maheswar Rupakheti and Mark Lawrence, Research Institute for Sustainability, Potsdam, Germany, and Ribu Cherian, University of Leipzig, Leipzig, Germany.

(S. Ramachandran)

Impact of lockdown restrictions and pollution events on nanoparticles in Delhi

Due to rapid urbanization, Delhi experiences frequent pollution events, and the particulate matter load exceeds the prescribed limit often. In this study, we have analyzed nanoparticles (in the 10 to 1090 nm radius range) during different emission scenarios, seasonal and meteorological conditions in two phases: April to June 2021 (Period I) and October to November 2021 (Period II). Period I experienced around 31% less concentration of particles ($\sim 2.4 \times 10^4$ cm^3) due to lockdown restrictions whereas on the other hand, the particle concentration increased by 35% compared to normal conditions due to the sudden rise in firework emissions (Diwali) in Period II. Except for the post-Diwali phase (10^4 cm^3 to 10^5 cm^3), the concentrations lie between 10^3 cm^3 and 10^5 cm^3. The small and large Aitken modes contribute 10 to 30% of total concentration in both periods. Particles in nucleation and accumulation modes contribute 30 to 40%, 20 to 30%, 15 to 25%, and 35 to 50% in Periods I and II, respectively. Number concentration-based studies are essential for estimating the potential impacts on human health due to air pollution. The study provides information regarding vehicle emission-based particle concentration under various emission scenarios in urban cities, which is crucial for estimation of emissions, health impact assessment, future policy formulation and strategy measures.

doi : https://doi.org/10.1016/j.uclim.2023.101625

This work was done in collaboration with K. Rajagopal (Ph.D. student under joint supervision with R.K. Mishra), and R.K. Mishra, Delhi Technological University, Delhi.

(S. Ramachandran)

Sources and Distribution of Light NMHCs in the Marine Boundary Layer of the Northern Indian Ocean during Winter: Implications to Aerosol Formation

Non-methane hydrocarbons (NMHCs) are ubiquitous trace gases and profoundly affect the Earth's atmosphere and climate change. Mixing ratios of light NMHCs were measured over the northern Indian Ocean during winter-2018 as a part of the Integrated Campaign for Aerosols, gases, and Radiation Budget (ICARB-2018).

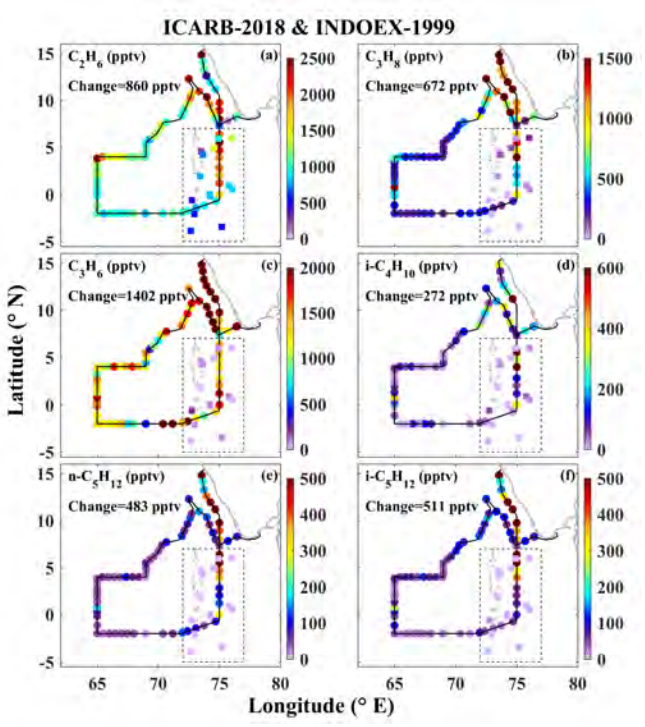

Figure 3: Spatial distributions of NMHCs measured during the ICARB-2018 and INDOEX-1999 campaigns. The dashed rectangle marks the common region for which the observed changes (enhancement) in the mixing ratios of NMHCs are labelled in the top-left corner.

Higher levels of NMHCs over the coastal regions were due to the efficient transport of anthropogenic and biogenic air masses and higher air-sea exchanges due to the higher biological productivity. Although oceanic emissions dominated the open ocean, the transport of aged continental air also influenced the levels of some NMHCs. The higher and lower propane/ethane ratios of 2.41 $\pm$ 0.34 and 1.13 $\pm$ 0.78 ppbv ppbv^{-1} over coastal and open oceans indicated the prevalence of fresh and aged air masses, respectively. Ethene and propene show a strong correlation, but the ethene/propene ratios over open ocean were slightly lower than the coastal region. Principal component analysis reveals the major associated sources identified in this study are from oceanic and nearby anthropogenic sources, explaining nearly 51% and 21% of variance. Light alkenes accounted for $\sim$70% of the total ozone and secondary organic aerosol formation potential. A higher alkene/alkane ratio, strong correlation of alkene with organic aerosol mass, and new particle formation events highlight the role of alkenes in secondary aerosol formation over the equatorial Indian Ocean. Overall, the levels of NMHCs were found to be much higher than those measured nearly two decades ago during the Indian Ocean Experiment (INDOEX)-1999 (Figure 3).

doi : https://doi.org/10.1029/2023JD039433

This work is done in collaboration with scientists from Space Applications Centre, Indian Space Research Organization, Ahmedabad, India and Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvananthapuram, India.

(L. K. Sahu & Nidhi Tripathi)

Detection of biogenic volatile organic compounds emitted from common tropical plant species in the Western Ghats region of India: chamber-based experiments

This study deals with the emission of biogenic volatile organic compounds (BVOCs) from plant species that are commonly found in the Western Ghats of India using branch enclosure experiments. A custom-made dynamic chamber system was deployed to collect samples from seven different plant species (Figure 4). Analysis of speciated BVOCs was performed using C2C6 and C6C12 VOC analysers to determine the emission composition and relative concentration. Isoprene was the most abundant compound, followed by ethene, propene, α-pinene and β-pinene. Among the plant species, Tectona grandis, Bambusa vulgaris and Psidium guajava showed high fractions of isoprene emission, Saraca asoca showed moderate emission, and Manilkara zapota and Leucaena leucocephala showed the lowest emission. However, M. zapota and L. leucocephala showed higher emission of both ethene and propene compared to isoprene. This study emphasizes the importance of emission flux measurements of major plant species in different forest regions of India, which is necessary to make emission inventories of important BVOCs.

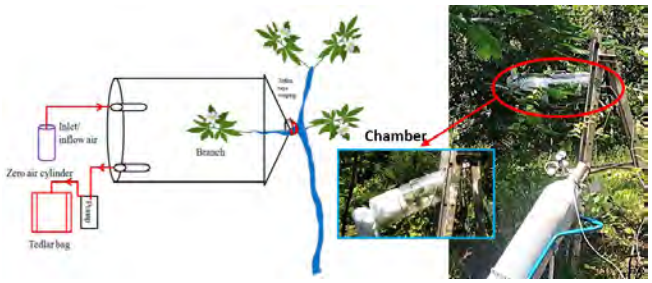

Figure 4: Schematic diagram (left) and field deployment (right) of the dynamic chamber system for the sampling of BVOCs emitted from different plant species.

doi : https://doi.org/10.18520/cs/v126/i1/59-66

This work is done in collaboration with the researchers from CSIR-National Institute of Oceanography (NIO), Dona Paula, Goa, India.

(T. G. Malik, Mansi Gupta, and L. K. Sahu)

Study of secondary organic aerosol formation and aging using ambient air in an oxidation flow reactor during high pollution events over Delhi

Secondary aerosols constitute a significant fraction of atmospheric aerosols, yet our understanding of their formation mechanism and fate is very limited. In this work, the secondary organic aerosol (SOA) formation and aging of ambient air of Delhi are studied using a potential aerosol mass (PAM) reactor, an oxidation flow reactor (OFR), coupled with aerosol chemical speciation monitor (ACSM), proton transfer reaction time of flight mass spectrometer (PTR-ToF-MS), and scanning mobility particle sizer with counter (SMPS + C). The setup mimics atmospheric aging of up to several days with the generation of OH radicals. Variations in primary volatile organic compounds (VOCs) and oxygenated volatile organic compounds (OVOCs) as a function of photochemical age were investigated. Primary VOCs such as benzene, toluene, xylene, trimethyl benzene, etc. decrease and OVOCs like formic acid, formaldehyde, acetone, ethanol, etc. substantially increase upon oxidation in OFR. The highest organic aerosol (OA) enhancement was observed for the 4.2 equivalent photochemical days of aging i.e., 1.84 times the ambient concentration, and net OA loss was observed at very high OH exposure, typically after 8.4 days of photochemical aging due to heterogeneous oxidation followed by fragmentation/evaporation. In ambient air, OA enhancement is highest during nighttime due to the high concentrations of precursor VOCs in the atmosphere. SMPS + C results demonstrated substantial new particle formation upon aging and decrement in pre-existing aerosol mass. This study provides the first experimental in-situ evaluation of potential SOA mass generated in ambient urban air of India.

doi : https://doi.org/10.1016/j.envres.2024.118542

This work is done in collaboration with the researchers from Indian Institute of Technology Delhi, India

(Nidhi Tripathi, Mansi Gupta, and L. K. Sahu)

Characterization of a Regional Dust Storm Using RAMAN Lidar Over the Western Indian Region

We investigated a dust storm (DS, on 5th May 2016) over a semi-arid western-Indian region, Ahmedabad using a ground-based Raman Lidar (RL), satellite datasets, and model simulations. The Moderate Resolution Imaging Spectroradiometer (MODIS) corrected reflectance images from Terra and Aqua satellites showed a heavy dust layer over the Ahmedabad region that was transported from the Arabian Peninsula and the Middle East. Horizontal visibility decreased sharply, falling less than 1 km on the DS day. RL is used to monitor the diurnal variation of the dust aerosol layer from the surface to about 3 km during DS. The retrieved aerosol optical depth (AOD) using the RL and MODIS shows high AOD values on the DS day (AOD$\sim$2.2 and 0.85) attributed to higher dust loading in comparison to normal days. Results indicate that the ultraviolet aerosol index (UVAI) increased twice ($\sim$3) during DS day in comparison with that of a dust-free day (UVAI$\sim$1.4). The WRF-Chem model reasonably reproduced the spatial distribution of PM_{10} and $PM_{2.5}$ concentrations, exhibiting higher concentrations during the DS when compared to ECMWF-CAMS.

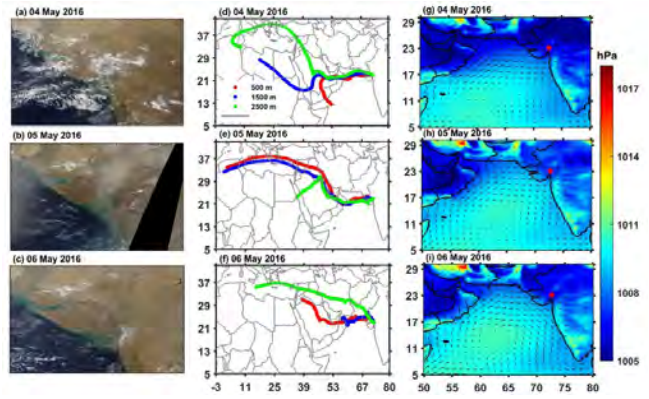

Figure 5: (ac) True colour corrected reflectance images of Terra/ MODIS (left panels) and the pass time of the satellites (Terra & Aqua) over the study region on 05 May 2016 is 06:25 and 07:55 UTC (df) 7 days air mass backward trajectory at Ahmedabad for three different altitudes 500 m, 1500 m and 2500 m (middle panels) (gi) ERA5 sea level pressure and 10 m wind vectors (right panels) during 0406 May 2016. The white and grey coloured patches in (a-c) indicates the cloud and dust in the reflectance images, respectively.

doi : https://doi.org/10.1007/s12524-023-01778-x

This work was done in collaboration with Kondapalli Niranjan Kumar (NCMRWF, MoES, Delhi), Prashant Kumar (SAC, Ahmedabad), Raju Attada (IISER, Mohali).

(Som Sharma, K. K. Shukla, Dharmendra Kamat, Sourita Saha)

Response of the boundary layer clouds to the surface forcings: A case study of western India

Clouds atop atmospheric boundary layer over an urban location have been studied using a ground-based Raman LIDAR (RL), supported by radiosonde, INSAT-3D and Meteosat-geostationary satellite, and ERA5 reanalysis datasets. The low-level clouds over Ahmedabad (23.02°N, 72.57°E) have been formed from the outflow of a large-scale convergence zone extending from the East-West Indian region. The persistence of these clouds throughout the day has been aided by the transport of moisture to cloud heights by turbulent updrafts. The cloud cover broke off with the entrainment of free tropospheric air with the deepening of the boundary layer, disrupting the surface moisture supply. The consecutive two days (10 and 11 June 2016) observations from the RL showed a unique sensitivity of these clouds to the diurnal variation of the atmospheric boundary layer due to the strong coupling between the clouds and the boundary layer. Ground-based LIDARs provide a better platform for studying the low-level boundary layer clouds and their sensitivity to surface forces due to high accuracy and high temporal resolution. Thus, increasing ground-based observations of such boundary layer clouds is essential for a better understanding of climate sensitivity.

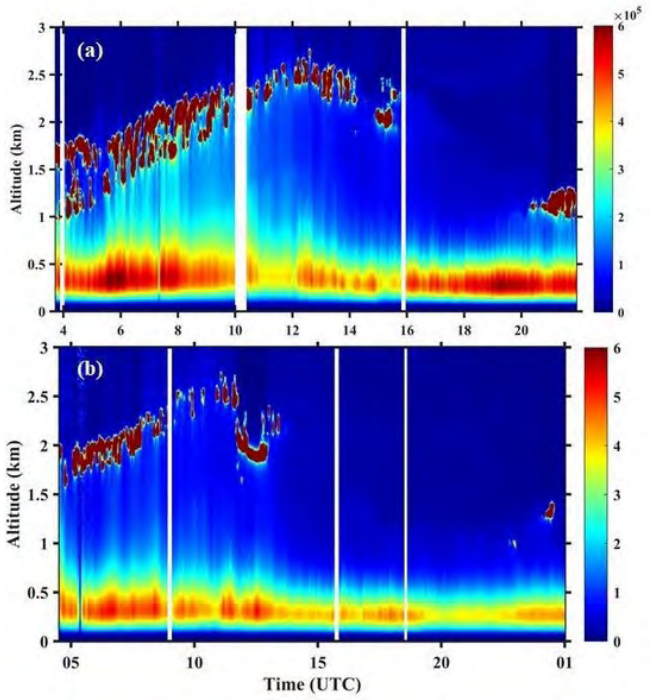

Figure 6: Range-Time Intensity plot of Range Corrected Backscattered Signals (in arbitrary units) received by Raman LIDAR on (a) 10 June (b) 11 June 2016.

doi : https://doi.org/10.1016/j.rsase.2023.101073

This work was done in collaboration with Prashant Kumar (SAC, Ahmedabad), Niranjan Kumar Kondapalli (NCMRWF, Noida), Hassan Bencherif (University De la Reunion, Reunion Island, France), Satish Chandra (PPN College, Kanpur, India).

(Som Sharma, Sourita Saha, Dharmendra Kamat, Shyam Lal)

A remote sensing algorithm for vertically resolved cloud condensation nuclei number concentration

Cloud condensation nuclei (CCN) are mediators of aerosolcloud interactions (ACIs), contributing to the largest uncertainties in the understandings of global climate change. We developed a novel remote-sensing-based algorithm that quantifies the vertically resolved CCN number concentrations (NCCN) using aerosol optical properties measured by a multiwavelength lidar. The algorithm considers five distinct aerosol subtypes with bimodal size distributions. The retrieved optically equivalent particle size distributions and aerosol-type-dependent particle composition are utilized to calculate critical diameters using κ-Khler theory and NCCN at six supersaturations ranging from 0.07% to 1.0%. Sensitivity analyses indicate that the uncertainties in extinction coefficients and relative humidity greatly influence the retrieval error in NCCN. The potential of this algorithm is further evaluated by retrieving NCCN using airborne lidar from the NASA ObseRvations of Aerosols above CLouds and their intEractionS (ORACLES) campaign and also

validated against simultaneous measurements from the CCN counter. The independent validation with robust correlation demonstrates promising results. Furthermore, the NCCN has been retrieved for the first time using a proposed algorithm from spaceborne lidar Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) measurements. The application of this new capability demonstrates the potential for constructing a 3D CCN climatology at a global scale, which helps to better quantify ACI effects and thus reduce the uncertainty in aerosol climate forcing

doi : https://doi.org/10.5194/acp-24-2861-2024

This work was done in collaboration with Dr. Piyush Kumar Patel of Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA and Oak Ridge Associated Universities, Oak Ridge, TN, USA and others

(Harish Gadhavi)

Surface ozone over Doon Valley in the Himalayas: Observations and model results

Surface ozone is a secondary pollutant that forms in the atmosphere through photochemistry of nitrogen oxides (NOx) and volatile organic compounds (VOCs) emitted from diverse anthropogenic and natural sources. Ozone plays vital roles in tropospheric chemistry besides deleteriously affecting human health and crop yields. Despite rapid growth in population and urbanization, systematic ozone measurements in the Himalayan foothills have been scarce and the performance of models have been limited due to complex topography and uncertain emissions. In this regard, ground-based measurements of ozone have been conducted over Doon valley during 2018-2023 and a comprehensive analysis has been conducted in conjunction with satellite measurements and CAMS model reanalysis. The observations revealed that the surface ozone levels are highest during the pre-monsoon due to intense regional photochemistry and outflow from the Indo-Gangetic Plain (IGP).

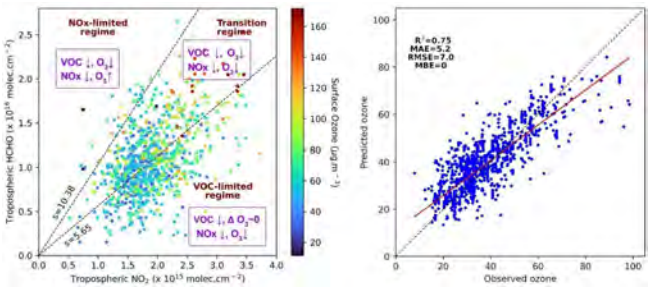

Figure 7: (Left) Satellite-derived tropospheric HCHO versus NO_2, color-coded with the observed surface O_3. (Right) Comparison of observed and GAM-simulated ozone variations.

Model, capturing the day-to-day variability in noontime ozone successfully, indicates that the regional photochemistry plays a dominant role. Analysis also shows that exposure to high ozone levels during pre-monsoon can affect human health and crop productivity of the region. Ozone formation is in VOC-limited or transition regime therefore reduction in both VOCs and NOx are necessary to control ozone levels (Figure 7). A statistical model (Generalized Additive Model), trained on observed ozone, satellite-derived tracers and meteorological reanalysis, could compute observed ozone variability quite well (r^2=0.75) (Figure 7). It is suggested that statistical and advanced machine learning techniques may help in filling the crucial observational gaps over the Himalayan region.

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This work has been performed in collaboration with I. Girach of SAC, Ahmedabad, K. Sharma of Graphic Era Dehradun, P. R. Nair and S. S. Babu of SPL VSSC, Thiruvananthapuram, N. Singh of ARIES Nainital and J. Flemming of ECMWF, UK

(S. Harithasree, L. K. Sahu and N. Ojha)

Effects of chlorine chemistry on atmospheric composition in contrasting urban environments

The chlorine (Cl) chemistry can significantly affect the oxidation capacity and consequently the atmospheric composition, especially in the urban environments. However, models typically lack detailed chemical mechanism of Cl and therefore its role is not well understood. In this regard, the gas and aqueous-phase Cl chemistry have been comprehensively updated in the community atmospheric chemistry box model - CAABA/MECCA (Figure 8).

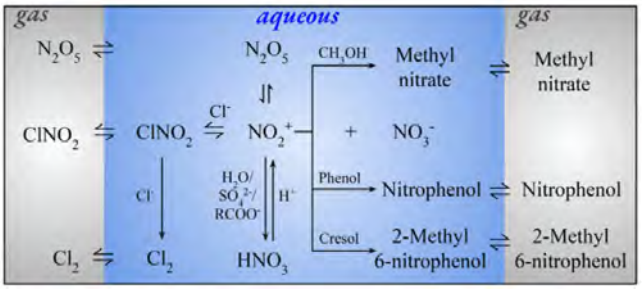

Figure 8: Aqueous-phase and heterogeneous chemistry added to the MECCA.

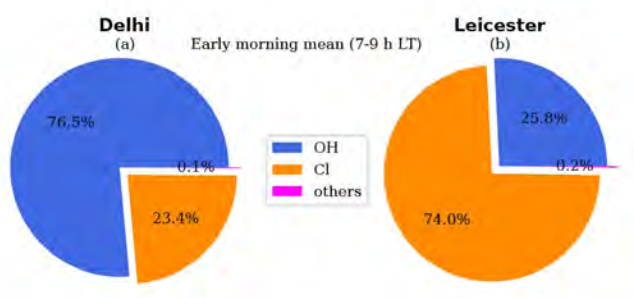

Figure 9: Atmospheric oxidative capacity of radicals during early morning in (a) Delhi and (b) Leicester.

In particular, an explicit mechanism for $ClNO_2$ formation following N_2O_5 uptake by aerosols has been developed. The updated model has been applied to simulate urban environments of contrasting NO_x conditions in South Asia (Delhi, India), and Europe (Leicester, United Kingdom). The model results highlight contrasting variations in night-time oxidant, nitrate (NO_3) radicals, with Delhi exhibiting unusually higher levels during the day ($\sim$0.1 pptv), while Leicester experiences higher levels after midnight ($\sim$2.6 pptv). Although the major production of Cl is from the photolysis of Cl_2 over Delhi, its productions through photolysis of $ClNO_2$, ClONO, and ClO + NO reactions are also prominent over Leicester. The higher ratios of Cl to OH reactivities in Leicester coincide with a stronger contribution of Cl to the atmospheric oxidation capacity, surpassing that of OH by approximately 3 times during the morning hours (Figure 9). As a result of Cl chemistry, the simulated concentrations of OH, HO_2, and RO_2 radicals are higher, especially near the sunrise. The model updates and simulation results have important implications for future studies on urban air quality and aerosol formation.

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This work has been done in collaboration with R. Sander, A. Pozzer from MPI-Chemistry, Germany; D. Taraborrelli from IEK-8, Jlich; P. Liu from Georgia Tech, USA; A. Patel, S. S. Gunthe from IIT Madras; and I. Girach from SAC, Ahmedabad

(Meghna Soni, L. K. Sahu, N. Ojha)

Impact of strong and weak stratospheric polar vortices on geomagnetic semidiurnal solar and lunar tide

The stratospheric polar vortex (SPV) is a band of strong winds that encircle the polar region and gets affected by vertically propagating planetary waves from lower below. This interaction leads to an increase in the stratospheric temperature and a reduction in the eastward winds which is also known as sudden stratospheric warmings (SSW). In the absence of planetary waves, eastward winds increase and the temperature remains low which is associated with the strong SPV. The state of the SPV modulates the atmospheric circulation which causes changes in the spectrum of vertically propagating atmospheric waves. In this work, we have investigated the impact of the strength of the northern hemispheric SPV on the ionosphere in 34 winters (during 15 December to 1 March) for 41 years (1980-2020). In order to do that, the equatorial electrojet (EEJ) variations, as obtained from Huancayo (12.05° S, 284.67° E; magnetic latitude: 0.6° S) are used. The Northern Annular Mode (NAM) values are used to define the strength of the SPV. The EEJ gets affected by the upward propagating solar and lunar tides which are generated in the lower atmosphere due to heating by solar radiation and gravitational force by the moon, respectively. We have investigated that the solar and lunar semidiurnal tidal amplitudes in the EEJ increase during the weak SPV, whereas, their amplitudes decrease during the strong SPV as can be seen in Figure 10. Our results also reveal that the response of the geomagnetic semidiurnal solar tidal variations to strong and weak SPV conditions is delayed by approximately 10 days while the response of geomagnetic semidiurnal lunar tidal variations does not show a time delay. These results provide observational evidence that along with weak SPV, the strong SPV also have pronounced effects on the equatorial ionosphere.

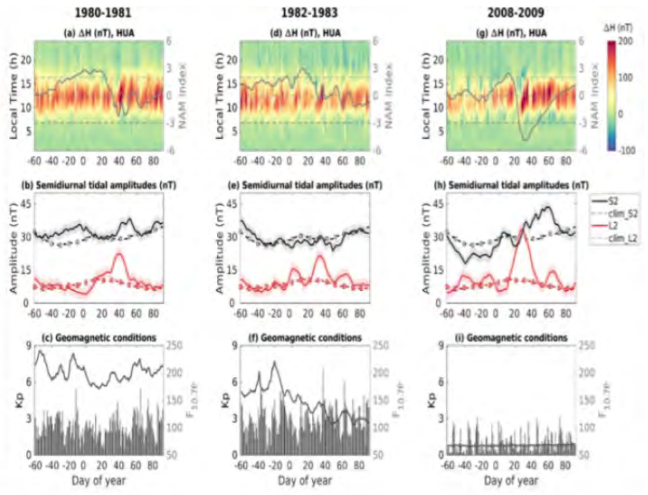

Figure 10: Panels a, d, and g show the local time EEJ variations from 1st November to 31st March for the winters of years 19801981, 19821983 and 20082009, respectively. The solid gray lines in the top panels represent the NAM values, while dashed gray lines correspond to the NAM value of 2 and -3 associated with the reference values for strong and weak SPV, respectively. In panels b, e, and h, the amplitudes of semidiurnal solar (solid black line) tide and its climatology (dashed black line) are shown for the same years as mentioned above. In a similar way, the amplitudes of semidiurnal lunar (solid red line) tide and its climatology (dashed red line) are shown in these figures. Panels c, f, and i show the daily averaged Kp values in black bars and daily $F_{10.7P}$ levels in solid gray lines.

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This work is done in collaboration with Tarique A. Siddiqui, Claudia Stolle at Leibniz Institute of Atmospheric Physics at the University of Rostock, Khlungsborn, Germany and Nicholas M. Pedatella, High Altitude Observatory, National Center for Atmospheric Research, Boulder, CO, USA.

(Sunil Kumar and Duggirala Pallamraju)

Imprint of storm enhanced density in ground-based OI 630.0 nm dayglow measurements

During the main phase of geomagnetic storm, a large enhancement in the plasma density in mid-latitude ionosphere is referred to as the storm enhanced density (SED) phenomena. SEDs have been studied by primarily by using total electron content (TEC) data. In this work, the high spectral resolution ground-based measurements of atomic oxygen 630.0 nm, $O^1(D)$, dayglow emissions were used as the primary dataset, as obtained from Boston (71°W, 42.36°N) in addition to other complimentary datasets, such as, Millstone Hill Incoherent scatter radar (ISR), GNSS TEC, DMSP. During a geomagnetic disturbance on 09 November 2004, the intensity of measured $O^1(D)$ dayglow emissions exceeded anomalously from their typical variation during local evening hours Figure 11. The underlying cause for such anomalous increase in brightness was confirmed due to the presence of overhead SED by investigating the measurements of local ionospheric parameters (electron density, temperature) from collocated ISR and TEC variations over a large scale. Further, we examined the rate of change of TEC index (ROTI) (figure 12) and

estimated vertical profiles of volume emission rates of these emissions using a physics-based model, GLOW, to understand the effects of high-mid latitude coupling in the overhead ionosphere and effects of ionospheric parameters on dayglow emissions. These results report the first optical signatures of SED in the daytime to the best of our knowledge and the associated ionospheric features.

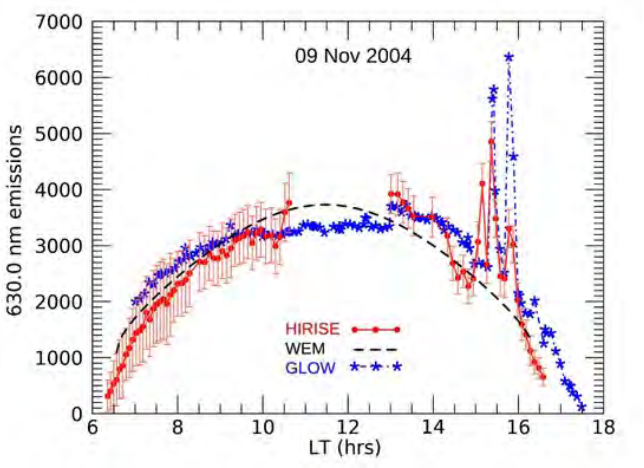

Figure 11: The ground-based measurement of O(^{1}D) dayglow emissions obtained using HighResolution Imaging Spectrograph using Echelle grating (HIRISE) on 09 November 2004 along with the estimates of WEM and GLOW model of O(^{1}D) emissions. The increased brightness can be seen during 15-16 LT dusk hours as measured by HIRISE.

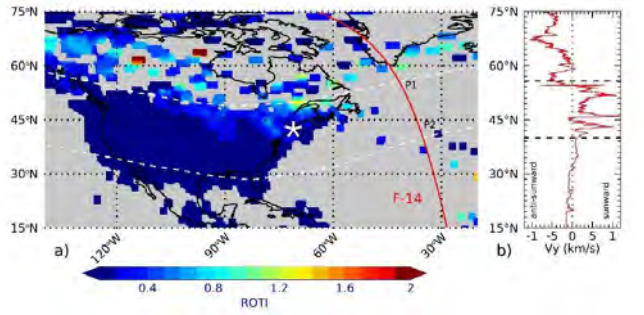

Figure 12: a) The ROTI variation showed the expansion of equatorward boundary of high latitude cell pattern below 60° magnetic latitude (upper white dash line) and to reach over the observation location (white star) during 15-16 LT. b) The fast sunward flow of plasma in 40-60° magnetic latitude was measured by DMSP which was associated with sub auroral polarization stream (SAPS) electric field.

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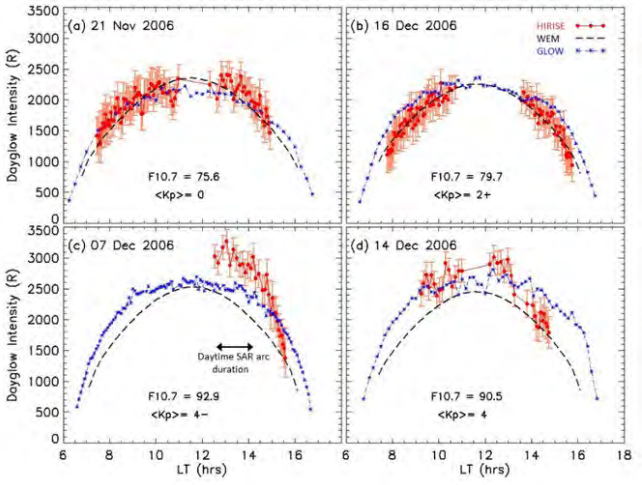
This work was done in collaboration with Prof. Supriya Chakrabarti of University of Massachusetts, Lowell, MA, USA.

(Kshitiz Upadhyay and Duggirala Pallamraju)

First daytime red-line emission measurements of the Stable Auroral Red (SAR) arcs

Stable Auroral Red (SAR) arcs are monochromatic atomic oxygen (630.0 nm) red line emissions which are zonally elongated but are latitudinally narrow. SAR arcs are formed during geomagnetic disturbances by the interaction of cold plasmaspheric particles with hot energetic ring current ions and manifest a direct evidence of magnetosphere-ionosphere (M-I) coupling in the mid-latitude upper atmosphere. SAR arcs are global in nature but are typically observed in the night sky using ground-based all sky imagers. Due to the presence of strong sunlight in background, their daytime detection becomes challenging. In this study, we have used daytime ground-based high spectral resolution OI 630.0 nm emissions during different geomagnetic quiet/active periods. These emissions were obtained from Boston (71°W, 42.36°N, magnetic latitude: 54°N), a mid-latitude location. On a disturbed day, 07 December 2006, the measured emissions were found to lie beyond the model estimated emissions (figure 13). The simultaneous measurements of electron temperature, Te, from collocated Millstone Hill Incoherent Scatter Radar (ISR) revealed an increased Te at higher altitudes. In addition, DMSP satellite data showed the existence of an enhanced Te peak collocated with the ionospheric trough over the observational magnetic latitude, which is a characteristic signature of SAR arcs thus confirmed the findings. Furthermore, forward modelling was performed between 200-650 km altitude to estimate the electron temperature associated with the measured daytime SAR arcs and was found to vary between 3500-4400 K. Therefore, these results present the first optical signature of SAR arcs during daytime and open up new possibilities to further investigate the underlying mechanisms of M-I coupling responsible for the dayside formation of SAR arcs.

doi : https://doi.org/10.1029/2023GL106292



The daytime O(^{1}D) emissions obtained using HighResolution Imaging Spectrograph using Echelle grating (HIRISE) are shown along with WEM and GLOW model outputs. Top and bottom rows the measured emission variation on quiet and disturbed days, respectively. The horizontal arrow in panel-c marks the duration of SAR arc emission observed during daytime.

(Kshitiz Upadhyay and Duggirala Pallamraju)

Quasi-two-day wave amplification through interhemispheric coupling during the 2010 austral summer

A quasi-two-day wave (QTDW) event during January-February 2010 is investigated using the MERRA-2 reanalysis dataset. MERRA-2 data

reveals the growth of the QTDW westward propagating wavenumber 3 preceded by a weak westward wavenumber 4. The diagnostic analysis suggests that the QTDW growth near tropical stratopause is mainly supported by barotropic (BT) instability in the presence of the summer easterly jet. BT instability during this event is suggested to be linked to the planetary wave breaking (PWB) in the winter hemisphere. The connecting link between the two appears to be the inertial instability (II) supported by the cross-equatorial transport of potential vorticity in association with PWB in the winter hemisphere which is consistent with the previous studies. Signatures of II are evident from the MERRA-2 temperature and wind anomalies in the vicinity of cross-equatorial transport of potential vorticity. One important observation brought out in this study is that the strength of meridional wind anomalies in the regions of the II appears to control the meridional curvature of the zonal mean zonal wind and, hence, BT instability of the jet. Overall, the temporal evolution of the QTDW at tropical stratopause during this event is consistent with the episodes of PWB, strength of meridional wind anomalies around the II and meridional curvature of zonal mean zonal wind. The latitude-altitude growth of the QTDW W3 in the zonal wind conforms to the location of critical layers and region of negative meridional gradient of potential vorticity.

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This work is done in collaboration with S. Gurubaran, Indian Institute of Geomagnetism, Navi Mumbai.

(Dupinder Singh, Gourav Mitra, Amitava Guharay, and Duggirala Pallamraju)

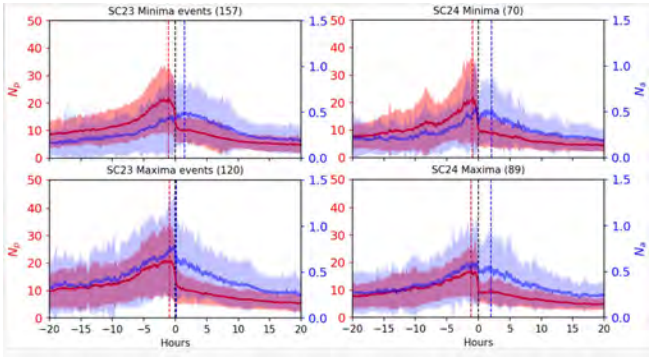

Figure 14: Superposed epoch analysis (SPA) of number densities of alphas (blue) and protons (red) are shown for the Stream Interaction Region (SIRs) events with one sigma error bar for SC23 minima, SC24 maxima, SC24 minima, and SC24 maxima (SC-Solar Cycle). The number of events is mentioned at the top of each panel. The dashed black, red, and blue vertical lines represent the Stream Interface (SI), the peak value of proton density towards the slow wind region (SWR), and the peak value of alpha density towards the fast wind region (FWR), respectively. The additional peaks of alpha particles towards the fast wind (in SC23 minimum and SC24) suggest the differential behaviour between the alphas and protons across SI. This suggests that the evolution of alphas and protons is different in SIRs.

In this work, by extensively analysing the SIR events observed in the solar cycles 23 and 24, it is shown that the stream interface of alphas starts separating out from that of protons from the minimum of solar cycle 23. The population of alpha particles are enhanced compared to protons at higher angles between bulk velocity and local magnetic field (henceforth, bulk velocity angle) in the fast wind region of SIRs if the background solar wind is taken as reference. The analysis of differential velocities between alphas and protons also reveals that the faster alpha particles accumulate near the fast wind side of the stream interface region leading to enhancement of A_{He}. The investigation brings out, for the first time, the salient changes in A_{He} in SIRs for the two solar cycles and highlight the importances of bulk velocity angle and differential velocity in the fast wind region for the changes in A_{He} in SIRs.

doi : https://doi.org/10.1093/mnrasl/slad112

(Yogesh, D. Chakrabarty and Nandita Srivastava)

New insights on the changes in the alpha to proton ratio (A_{He}) in the Stream Interaction Region

Although the enhancements in the alphaproton ratio in the solar wind (expressed as A_{He} = Na/Np*100) in the interplanetary coronal mass ejections have been studied in the past, A_{He} enhancements at the stream interface region (SIR) received a very little attention so far.

Evidence of magnetic islands at 1 au in accelerating suprathermal particles in the presence of a stream interaction region

Stream interaction regions (SIRs) are often thought to be responsible for the generation of suprathermal population in the interplanetary medium. Even though the source is the same, wide variations in the spectral indices of suprathermal populations are observed at 1 au during SIRs.

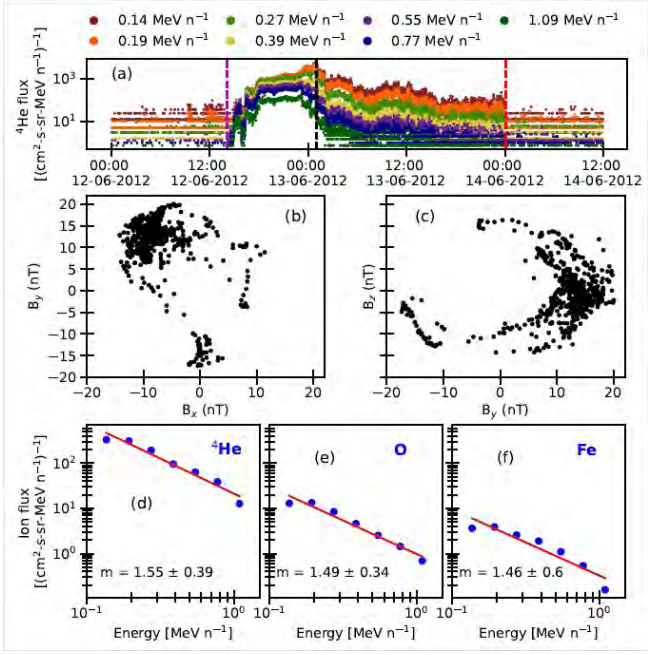

Figure15: (a) Enhancements in ^{4}He (only shown here), O, and Fe fluxes associated with a stream interaction region (SIR) as observed by Solar Terrestrial Relations Observatory Ahead (STEREO-A) satellite. (b) and (c) represent hodograms of the components of interplanetary magnetic field (IMF) during the interval between the start (vertical dashed magenta line) and peak (vertical dashed black line) of flux enhancement. Panel (d), (e, and (f) show the spectra of ^{4}He, O, and Fe during the entire flux enhancement period (interval between magenta and red dashed vertical lines). The spectral indices of these three elements with different mass-to-charge ratio are observed to be nearly identical and very close to 1.5.

This poses a significant uncertainty in understanding the generation of suprathermal ion populations by SIRs and indicates an interplay of multiple source mechanisms. By analyzing variations in suprathermal ^{4}He, O, and Fe for 20 SIR events recorded by STEREO-A during 20072014, it is found that the spectral indices of these elements vary in the range of 2.064.08, 1.854.56, and 2.114.04 for 19 events. However, in one special case, all three suprathermal elements show nearly identical ($\sim$1.5) spectral indices. The possible mechanisms that might cause significant variations in the spectral indices of suprathermal particles are investigated. It is also shown that the merging and/or contraction of small-scale magnetic islands near 1 au might have produced nearly identical spectral indices for three different elements with different first ionization potentials and mass-to-charge ratios. The occurrence of these magnetic islands near 1 au also supports the minimal modulation in the spectral indices of these particles. It is also suggested that a solar flare might have played a role in generating these magnetic islands near the heliospheric current sheet.

doi : https://doi.org/10.3847/1538-4357/ad08c6

(Bijoy Dalal, Dibyendu Chakrabarty, Nandita Srivastava, and Aveek Sarkar)

Characteristics of X-class flares of solar cycles 23 and 24 in X-ray and EUV bands

Understanding the characteristics of X-class flares is important as it not only throws light on the complex solar processes but also helps to evaluate the impact of these flares on the terrestrial ionosphere. In this investigation, flares during solar cycles 23 and 24 are examined based on the soft X-ray (0.10.8 nm) and EUV (2634 nm) light curves. The X-ray to EUV proportion of energy is found to be larger in the high X-class flares (X9.0 class and stronger) as compared to the flares weaker than X9.0 class. The X-ray and EUV light curves revealed that the time of impulsive and thermal EUV peaks differed from X-ray peak by $\sim$025 min. The time differences had a broad range for weaker flares but reduced to within $\sim$7 min for high X-class flare events. The study brings out the general energetics and temporal evolution of phases of the X-class flares.

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This work is done in collaboration with Kuldeep Pandey, G. C. Hussey [ISAS, Department of Physics and Engineering Physics, University of Saskatchewan, Saskatoon, Saskatchewan, Canada], S. Biswal [Solar Physics and Space Plasma Research Center (SP2RC), School of Mathematics and Statistics, University of Sheffield, Sheffield, UK]

(D. Chakrabarty, A. Kumar, Anil Bhardwaj, A.K. Yadav)

A case study of mesospheric frontal interaction and associated processes over the western Himalaya

The mesospheric bore is characterized by a sharp propagating mesospheric wavefront with a large horizontal extension in the airglow images. Bore could generate a trail of waves behind its leading front, unlike a typical mesospheric front. Sometimes, it divides the sky into dark and bright areas, showing out-of-phase intensity variation between adjacent airglow emission layers. The present work deals with a unique observational evidence of a mesospheric bore interaction with a typical mesospheric front in O(^{1}S) 557.7 nm airglow emission (Peak height 97 km) and underlying physicochemical processes, on the night of 25 April 2022 from a Himalayan station at Hanle (32.78°N, 78.97°E), Ladakh, India. In this study, we investigate the mesospheric bore in the presence of another frontal structure using a ground-based all-sky imager and the SABER instrument onboard the TIMED satellite. The results highlight the presence of a stable thermal duct that acts as a channel for propagating the mesospheric bore. Chemical heating is believed to be a causative mechanism in generating the thermal duct. The bore front shows an anti-clockwise rotation with time which is attributed to the differential phase speed between the extreme parts of the bore due to variations in duct depth. The bore propagation in the duct layer is suggested to push the underlying OH airglow emission layer downward (Figure 16).

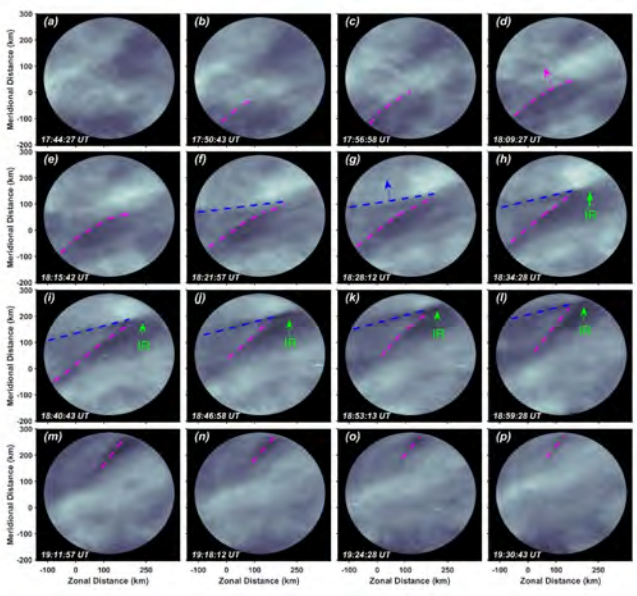

Figure 16. Sequence of O(^{1}S) 557.7 nm airglow images on 25 April 2022 over the western Himalayan region at Hanle, Leh Ladakh (32.78°N, 78.97°E). The images depict the evolution of the dark mesospheric bore structure (magenta) and its interaction with a dark mesospheric front (blue). Green arrows indicate the dark patchy interaction region (IR) on the eastern end of the fronts.

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This research work was done in collaboration with S. Sarkhel [Department of Physics, Indian Institute of Technology, Roorkee, India], M. V. Sunil Krishna [Department of Physics, Indian Institute of Technology, Roorkee, India], M. G. Mlynczak [Atmospheric Sciences Division, NASA Langley Research Center, Hampton, VA, USA].

(S. Mondal and A. Guharay)

Signature of two-step non-linear interactions associated to zonally symmetric waves during major sudden stratospheric warmings

The sun-synchronous semidiurnal tide (SW2) is a major wave in the middle and high latitude mesosphere and lower thermosphere (MLT). Sudden stratospheric warming (SSW) is a polar winter hemispheric event characterized by an enhanced planetary wave (PW) activity. Non-linear interaction between the two waves produces secondary waves whose frequencies are sum and difference of the primary waves. Further, the secondary waves, having a frequency closely spaced to the tidal frequency, beat with the tide, resulting in modulation of the tidal amplitude by the PW's period due to the non-linear interaction.

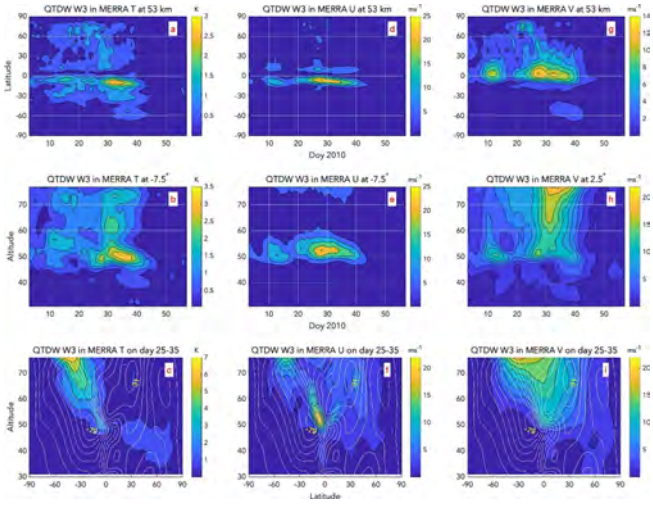

Figure 17. (a) Evolutionary Lomb Scargle amplitude spectra (semidiurnal tide [ST] period range) and (b) wavelet amplitude spectra (planetary wave period range) of the U at 90 km, and (c) wavelet spectra of the instantaneous ST amplitude at 90 km using meteor radar observations at Andenes (69.3°N, 16°E), from 1 November 2008 to 31 March 2009. (df) Represent the same as (ac) but during 20122013. The solid vertical line represents the peak warming day and the thin tilted line represents the cone of influence. The white curve in the wavelet spectra represents the 95% confidence level. Please note the change of scale in the colorbars corresponding to each subplot while comparing. The letters N, D, J, F, and M in the x axis denote November, December, January, February, and March; the subsequent number indicates the day of the given month.

The spectral analysis of specular meteor radar-derived hourly winds supports this notion, and hence provides evidence for non-linear interactions in the MLT. The dominant PW involved in the interaction is found to be zonally symmetric. The non-linear interaction between the stationary PW and propagating PW in the stratosphere plays an important role in forcing the zonally symmetric component, that can reach MLT altitudes. Furthermore, non-linear interaction between SW2 and the zonally symmetric PW produces the observed secondary waves in the MLT in the form of side bands in radar spectra. Overall, the present study provides the first observational evidence of a two-step non-linear interaction during SSWs (Figure 17).

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This research work was done in collaboration with J. L. Chau [Leibniz Institute for Atmospheric Physics, Khlungsborn, Germany] and J. F. Conte [Leibniz Institute for Atmospheric Physics, Khlungsborn, Germany].

(G. Mitra and A. Guharay)

Impact of sudden stratospheric warming on middle atmospheric circulation in the Southern hemisphere

Sudden stratospheric warming (SSW) is an extreme meteorological event where the polar vortex is disrupted, leading to a significant increase in temperature. This usually happens more in the Northern Hemisphere than in the Southern Hemisphere (SH). However, in September 2002 and 2019, rare SSW events occurred in the SH around the spring equinox, a seasonal transition from winter to spring.

The present study compares middle atmospheric circulation during

rare SH SSWs in 2002 and 2019. By removing seasonal effects (detrending), it focuses solely on the warming's impact on the global circulation. The detrended winds show a noticeable westward influences in the lower altitudes around the peak warming day. Westward winds in the extratropical stratosphere suggest a possible tropical connection to the SSW. Interestingly, although the 2019 SSW is a minor event, it caused a noticeable changes in the global circulation patterns. Overall, the study provides valuable insights into the impact of SH SSWs on the middle atmospheric circulation (Figure 18).

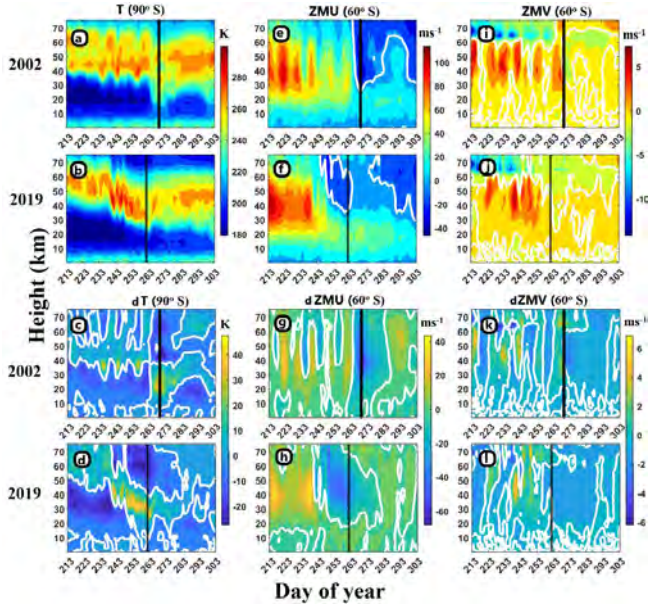

Figure 18. Time-height section of (a) T at 90°S, (e) zonal mean zonal wind (ZMU) at 60°S, and (i) zonal mean meridional wind (ZMV) at 60°S during 2002 observational days and (b) temperature (T) at 90°S, (f) ZMU at 60°S, and (j) ZMV at 60°S during 2019 observational days. Same for (c) dT at 90°S, (g) detrended ZMU at 60°S, and (k) detrended ZMV at 60°S during 2002 observational days and (d) detrended T at 90°S, (h) detrended ZMU at 60°S, and (l) detrended ZMV at 60°S during 2019 observational days. The solid vertical line represents the peak warming day. The white bold curves represent zero values in all the plots. Please note the change of scale in the colorbars corresponding to each subplot while comparing. Also, consider the difference in colorbar used to represent actual and detrended variability.

doi : https://doi.org/10.1016/j.jastp.2024.106173

(G. Mitra and A. Guharay)

Parametric dependence of topside ionospheric profiles in NeQuick2 model and its consequences on the estimation of TEC over the equatorial and low latitudes

Constructing realistic vertical electron density profiles is a crucial step in accurately estimating the ionospheric Total Electron Content (TEC) using empirical models. Inadequate representation of electron density profiles leads to an under- or over-estimation of TEC in the model outputs. One of the widely used ionospheric empirical model, the NeQuick2 exhibits large uncertainties over equatorial and low latitudes, particularly in the topside ionosphere. The NeQuick2 model employs semi Epstein type of polynomials to characterize the topside ionospheric structure, wherein, the scale height (H) is the key parameter. NeQuick2 model estimates H value using empirical formulations, which contain three major parameters namely, Ho the scale height at the F-layer peak, g height gradient in H, and r which controls the increase in H at higher altitudes. A systematic analysis has been carried out with a particular focus on the equatorial and low latitudes to explore the variability of topside scale height and electron density profiles on the above three empirical parameters using COSMIC observations over Trivandrum and Ahmedabad, in India. It is observed that the deviations in Ho significantly affect the scale height and electron density distributions in the topside ionosphere over the equatorial and low latitudes. The NeQuick2 model does not reproduce the observed diurnal and latitudinal variations in the Ho parameter. Larger deviations in modelled Ho are observed during daytime hours at the crest and trough of the Equatorial Ionization Anomaly. Data assimilation analysis revealed that uncertainties in TEC significantly reduced after ingesting the observed values of N_mF_2 and Ho, with much lower deviations during the low solar activity period (figure 19).

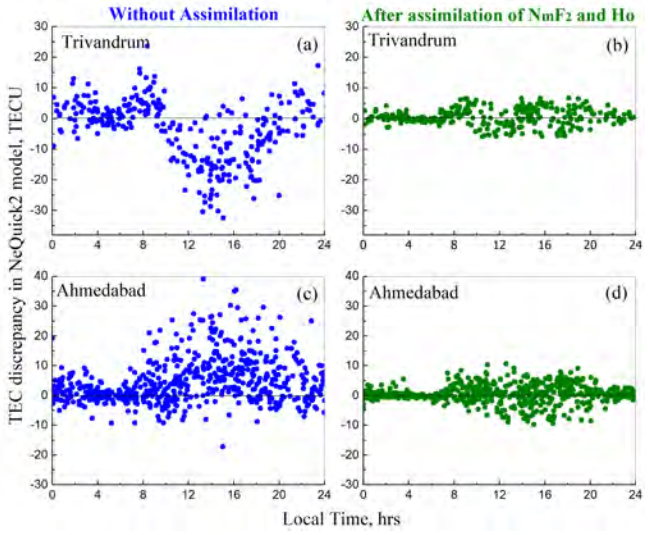

Figure 19: Discrepancies in NeQuick2 modelled TEC (a & c) without data assimilation and (b & d) with assimilation of N_mF_2 and Ho values from COSMIC radio occultation data over Trivandrum and Ahmedabad during the high solar activity period 2013-2014.

This study demonstrates the important role of scale height on the uncertainties in modelling the topside density profiles and the complexity involved in developing accurate formulations for the equatorial and low latitude ionospheric TEC modelling. This shows the need for improvements in the formulations of the topside scale height for achieving better accuracy in models over the equatorial and low latitude sectors.

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This work was done in collaboration with T. K. Pant of Space Physics Laboratory, Thiruvananthapuram, India.

(K. Venkatesh, D. Pallamraju and P. Suryawanshi)

Statistical analysis on the ionospheric response to 70 intense geomagnetic storms occurred over two decades

The statistical response of the ionospheric Total Electron Content (VTEC) during 70 geomagnetic storms at mid and near high latitude regions in the Antarctic and Argentine/Chilean sectors in the Southern hemisphere are investigated. This study covers a period of two decades from 1999 to 2018, during which, a total of 70 intense geomagnetic storms (Dst $\leq$ -100 nT) occurred. The ionospheric response during storms is categorized as positive, negative, positive-negative and negative-positive based on the increase or decrease in TEC during storm period with respect to the pre-storm conditions. The occurrence of geomagnetic storms follows a pattern of solar activity dependence. The ionospheric response during geomagnetic storms indicate that the positive phases occur more frequently during the daytime while the negative phases occur predominantly in nighttime. Storm time TEC response also shows notable seasonal dependence with positive and positive-negative phases during autumn, winter, and spring at mid-latitudes and winter at near high-latitudes. Negative and negative-positive phases occur during all seasons at near high- and mid-latitudes. There is also a predominance of positive and positive-negative phases simultaneously at near high- and mid-latitudes in the Antarctic and Argentine/Chilean sectors. The percentages of occurrence of positive and positive-negative phases are of 50% and 19%, respectively, at mid-latitude and 60% and 22%, respectively, at near high-latitudes. Negative and negative-positive phases are below 9 at both latitudes. Observations from this study assist in the improvement of models and understanding the processes with regard to the effects of the space weather in the mid- and high-latitude regions and consequent impacts on the ionospheric storms at lower latitudes.

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This study was done in collaboration with A. J. de Abreu, E. Correia and R. de Jesus of Instituto Nacional de Pesquisas Espaciais, Brazil, P.R. Fagundes of Universidade do Vale do Paraiba, Brazil, E.P. Macho of Universidade Presbiteriana Mackenzie, Brazil, M. Roberto of Instituto Tecnologico de Aeronautica, Brazil and M. Gende of Universidad Nacional de La Plata, Brazil.

(K. Venkatesh)

Planetary Sciences

Modelling of Planetary Atmosphere, Simulations and Interstellar Medium

Turbulence dynamics in the inner solar corona from radio sounding experiments using the Akatsuki spacecraft

Using the Akatsuki spacecraft, during the 2021 Venus-solar conjunction event, the coronal radio-sounding experiments are conducted in the inner heliosphere to study the characteristics of plasma turbulence and flow speeds. The X-band radio signal obtained at the two ground stations (Indian Deep Space Network in Bangalore, and Usuda Deep Space Center in Japan) was spectrally analysed to find the Doppler residual values. The turbulence spectrum showed the presence of an extended flatter source regime along the entire range of heliocentric distances. Using the quasi-static turbulence model, we estimated the flow speed of the turbulent plasma in the proximate ray path (the closest path of the radio waves to the solar surface). The flow speeds in the inner coronal regions between 5 and 13 solar radii are estimated to be 220550 km s^{-1}, which is higher than the expected average flow speeds in this region. The SDO/AIA EUV coronal images showed the presence of a large coronal hole, which explains the flatter slopes in the turbulence spectrum even with the increasing heliocentric distances and relatively higher flow speeds. This study provides unique insights into the least-explored inner coronal region by corroborating radio-sounding results with EUV observations of the corona, since the solar inner corona is a region that plays a critical role in energizing the solar wind and propelling it to supersonic and supra-Alfvenic velocities.

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This work was carried out in collaboration with Richa N. Jain and R. K. Choudhary of Space Physics Laboratory, VSSC, Trivandrum; T. Imamura of University of Tokyo, Chiba, Japan; and Anshuman Sharma and Umang M. Parikh of ISTARC/ISRO, Bengaluru.

(Anil Bhardwaj)

Moon: Plasma Sheath around Chandrayaan-3 Landing Site: A Case Study

A simulation of a realistic scenario and investigation of the electric potential development over the Chandrayaan-3 landing site under the influence of observed solar ultraviolet/extreme-ultraviolet radiation and real plasma parameters measured by THEMIS was carried out as a case study. The electric potential structures have been derived by solving Poisson's equation, which is coupled with the latitude-dependent fermionic photoelectrons, non-Maxwellian plasma electrons, and cold ions. A dynamic variation of the potential structure around the sunlit landing site has been observed through the analysis. This study predicts a photoelectron density range from 10 to 40 cm^{-3} and mean energy range from 2.6 to 3 eV near the surface of the Chandrayaan-3 landing site, which may be tested by the in-situ measurement.

doi : https://doi.org/10.3847/PSJ/acf1a1

(Sanjay K. Mishra and Trinesh Sana)

Magnetically controlled ionopause boundary at Mars

Earlier studies have reported that the Martian ionopause is not always formed and it lacks a static boundary, when it is formed. Studies further showed that when the solar wind dynamic pressure is low relative to the ionospheric thermal pressure, the ionopause is narrow and clear and its altitude is high.

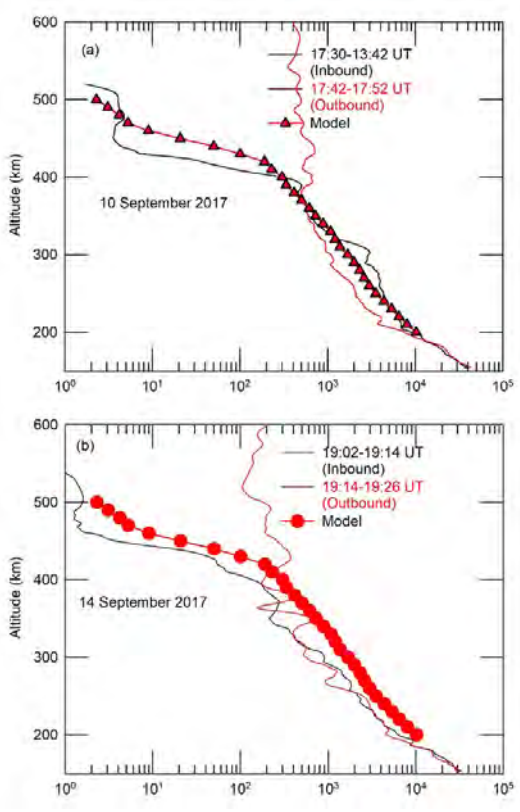

Figure 1: Comparison of the electron density profiles observed on (a) 10 September 2017 and (b) 14 September 2017 with the model results. The inbound profiles represent the ionopause-like structures. The ionopause-like structures are not observed in the outbound electron density profiles at night.

When the solar wind dynamic pressure is relatively high, the ionospheric thermal pressure alone is not sufficient to balance it, and the ionosphere becomes magnetized with large-scale horizontal fields. However, this aspect could not be unambiguously deciphered due to lack of simultaneous measurements of the solar wind, magnetic field and the ionosphere. We have used the data of MAG, NGIMS, and LPW instruments onboard NASAs MAVEN spacecraft, to fully characterise the ionopause at Mars for the first time. We have analysed plasma and magnetic field data obtained from 627 orbits of Mars Atmosphere and Volatile Evolution (MAVEN) that occurred during October 2014, April 2015, September 2017 and May 2018, when the spacecraft was crossing the magnetic pile-up boundary of Mars. Two broad peaks and a drop are observed in this magnetic field region. The magnetic cavity boundary lies between the ionosphere and the magnetic pile-up boundary. A steep ionopause like boundary is observed in 24 profiles of 627 orbits, when MAVEN was passing from the magnetic pile-up region during the daytime ionosphere in the presence of a horizontal magnetic field of high strength. In contrast, the night-side ionosphere did not show such boundary in presence of horizontal magnetic field of low strength (Figure 1). These profiles are unique and have not been reported earlier. We propose that the horizontal magnetic field can form such ionopause within the magnetic pile-up boundary during the daytime if the time and location of the magnetic anomaly coincide with the ion and electron density measurements. The night-time ionosphere is thought to be produced within the magnetic pile-up boundary due to the transportation of plasma from dayside to nightside across the terminator by a horizontal plasma flow velocity as has been predicted by the previous studies.

doi : https://doi.org/10.1016/j.icarus.2022.115423

(S. A. Haider, K. Durga Prasad and Siddhi Y. Shah)

Phobos and Deimos as Source of Dust Observed by Juno Spacecraft

Juno observations show dust halo near Mars, contributing to Zodiacal light, the source of which is yet to be known. In this work, we investigate the role of Phobos and Deimos as likely sources of interplanetary dust near Mars. Incoming dust at the Martian moons impact their surface and produce ejecta, a part of which can escape easily to space, as illustrated in Figure 2.

Results of escaping mass rates are presented and compared with incoming mass rates through a parameter called Mass Escape Ratio (MER). The results (Figure 3) show higher ratio for a wide range of particles, inferring a large amount of effective mass loss from the moons. A part of the escaping mass from the Martian moons get released from the Mars system after a period of time. Since, incoming dust continuously creates the ejecta from Phobos and Deimos, the process of particle release after the lifetime is also continuous. On the other side, the interplanetary dust flux is derived from Juno observations of dust impact rates between 1 to 5 AU heliocentric distance. An increase in the flux observed by Juno around 1.5 AU and the results of larger, continuous escaping mass from the moons indicate Phobos and Deimos to be the local sources of dust bands observed by Juno spacecraft.

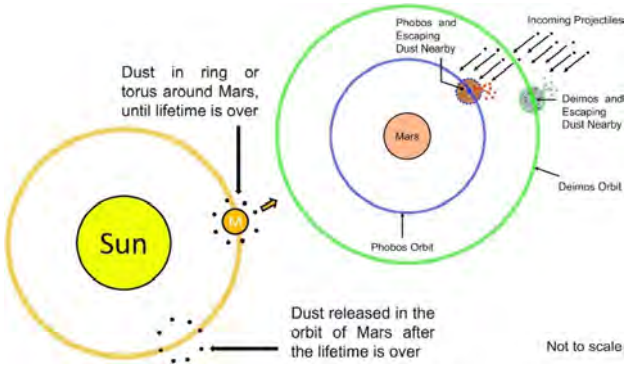

Figure 2: Illustrative diagram showing incoming projectiles on Martian moons and escaping particles around them (not to scale).

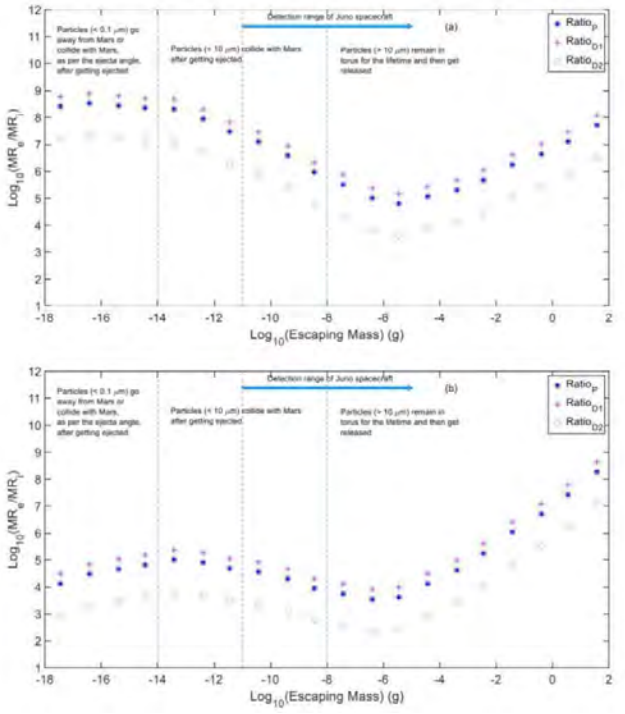

Figure 3: Results of MER for Phobos, Deimos in Case 1 and Deimos in Case 2 in (blue) asterisk mark, in (magenta) plus sign and (red) circle, respectively, as a function of escaping particle mass, with (a) normal incidence on the surface and (b) other incidences on the surface.

doi : https://doi.org/10.1093/mnras/stad1045

(J. P. Pabari)

The magnetically controlled ionopause boundary of Mars

Mars Atmosphere and Volatile Evolution (MAVEN) carries a suite of plasma and field instruments namely magnetometer (MAG), Neutral Gas Ion Mass Spectrometer (NGIMS), Langmuir Probe and Waves (LPW) and Solar Wind and Ion Analyser (SWIA).

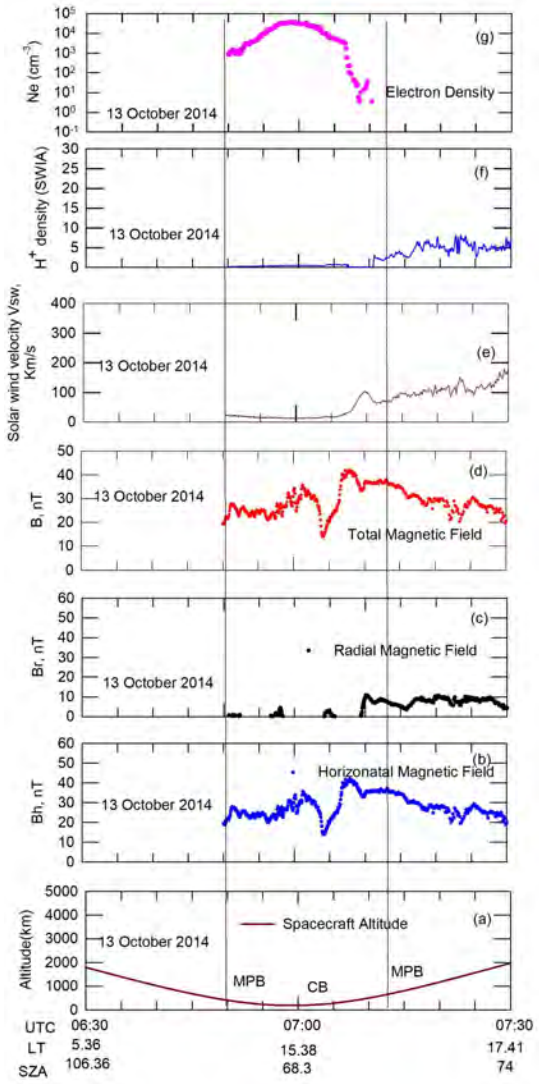

Figure 4: A time series of the spacecraft orbit (a), horizontal magnetic field (b), radial magnetic field (c), total magnetic field (d), H^+ density, (e), and electron density (f) respectively, when the MAVEN was passing from Magnetic Pile-Up Boundary (MPB) and Cavity Boundary (CB) on 13 October 2014. At the bottom of the figure, the Local Time (LT) and SZA of the spacecraft passing from dayside to nightside on Mars are shown. The horizontal magnetic field is of high strength, while radial magnetic field is low inside the MPB region. The electron density represents a broad peak in the CB region.

We have analysed 627 orbits of MAVEN during October 2014, April 2015, September 2017 and May 2018. These ionopause boundaries are controlled by the horizontal magnetic field within the magnetic pile-up region at SZA $\sim$60° to 110°. Figure 4(a-f) shows a time series of the spacecraft altitude (a), horizontal magnetic field, B_H (b), radial magnetic field, B_r (c), total magnetic field, B (d), proton density, H^+ (e), and electron density, Ne (f) observed by MAG, SWIA and LPW on 13 October 2014. The magnetic pile-up boundary is identified where the magnetic field shoots-up quickly by 20 nT. In this region two broad peaks were observed in the magnetic fields. The cavity boundary is located between these two magnetic field peaks. In Figure 4(d) the total magnetic field is dominated by the horizontal magnetic field because the radial magnetic field is very small (see Figure 4(b-c)). The horizontal magnetic fields are suddenly increased by a factor of 3-4 within the magnetic pile-up boundary. This confirms that the interplanetary magnetic field (IMF) draping in the magnetic- pile-up boundary is mainly horizontal. In this figure two broad peaks and a drop in the time series of the horizontal magnetic fields have been observed inside the magnetic pile-up boundary. In Figure 4(f) the LPW has observed peak electron density of the order $\sim 10^4$ to 10^5 cm^{-3}. It has been observed that the electron densities in the daytime ionosphere are suddenly reduced in the presence of the horizontal magnetic field of high strength during the inbound or outbound orbit of MAVEN within the magnetic pile-up boundary. The horizontal magnetic field inhibits the upward diffusion of plasma and reduces the electron densities within this altitude range by 1-2 orders of magnitude as shown in Figure 4 from a-f.

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(S. A. Haider, K. Durga Prasad and Siddhi Y. Shah)

Chemistry of hydrated, nitrogenated and deuterated cluster ions: NOMAD observations

The ExoMars Trace Gas Orbiter (TGO) instruments, Nadir and Occultation for Mars Discovery (NOMAD) and Atmospheric Chemistry Suite (ACS) have provided vertical profiles of H_2O and HDO mixing rations in the presence and absence of Global Dust Storm (GDS) 2018.

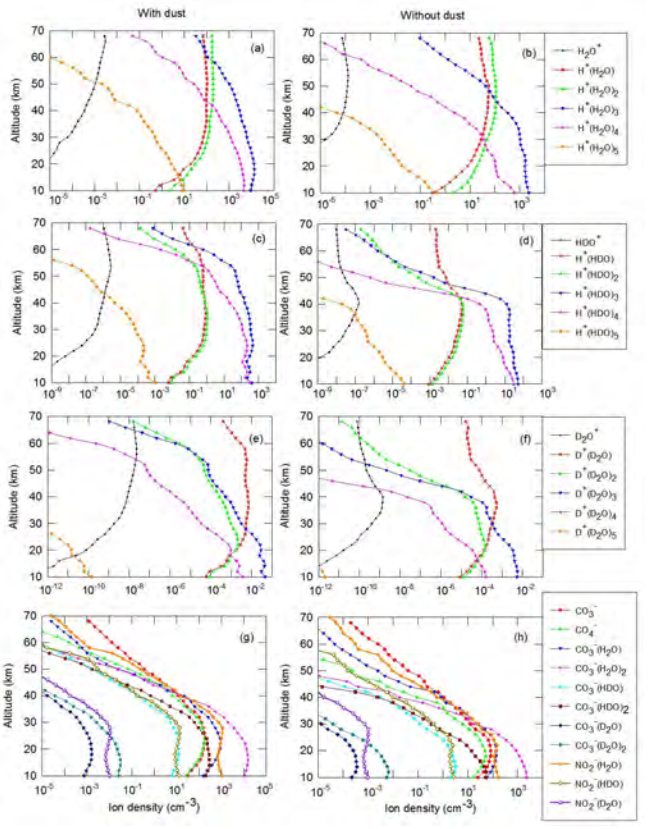

Figure 5: Altitude profiles of the densities of water, deuterated, and nitrogenated cluster ions (H_2O^+, D_2O^+, HDO^+, $H^+(H_2O)_n$, $D^+(D_2O)_n$, $H^+(HDO)_n$, CO_4^-, CO_3^-,$CO_3^-(H_2O)_n$, $CO_3^-(D_2O)_n$, $CO_3^-(HDO)_n$, $NO_2^-(H_2O)$, $NO_2^-(HDO)$, and $NO_2^-(D_2O)$ for n=1 to 5) due to impact of hard X-ray in model 1 (figures a, c, e, and g) and model 2 (figures b, d, f and h).

These observations are carried out in the lower atmosphere at SZA $\sim$71° of northern mid-latitude ($\sim$55°N, 130°E). Using NOMAD observations chemical model 1 and 2 was developed for dust and non-dust storm conditions, respectively. The production/loss rates of H_2O, HDO and D_2O and the densities of water, nitrogenated and deuterated cluster ions (H_2O^+, D_2O^+, HDO^+, $H^+(H_2O)_n$, $D^+(D_22O)_n$, $H^+(HDO)_n$, CO_4^-, CO_3^-, CO_3^- $(H_2O)_n$, $CO_3^-(D_2O)_n$, $CO_3^-(HDO)_n$, $NO_2^-(H_2O)$, $NO_2^-(HDO)$, and $NO_2^-(D_2O)$ (for n =1 to 5)) are estimated in Figure 5 from these models between 10 km and 70 km. We have used two ionization sources: (1) Galactic Cosmic Rays (GCR) and (2) hard X-ray in both models. The D peak density produced by GCR is lower by a factor of $\sim$5 than that produced by the hard X-rays. In model 1 the electron densities were increased by a factor of $\sim$ 2-3 than that produced by model 2. The estimated production/loss rates of H_2O, HDO and D_2O are also larger by an order of magnitude in model 1 than that estimated by model 2.

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(S. A. Haider and Siddhi Y. Shah)

Using a Quench Level Approximation to Estimate the Effect of Metallicity on the Abundances of N-bearing Species in H_2-dominated Atmospheres

N-bearing species are abundant in our solar system planets and are assumed to be also in the exoplanet atmosphere. A recent study suggests that these species can have the potential to open a new window to constrain the formation pathways. These species' thermochemical abundance depends on the thermal profile and elemental abundance. However, the atmospheric abundance of these species is primarily affected by the disequilibrium processes (vertical mixing and photochemistry). Studies on its thermochemical equilibrium composition are made; however, the effect on the disequilibrium composition must be better constrained. We have studied the effect of atmospheric metallicity on the composition of NH_3, N_2, and HCN over a large parameter space in the presence of vertical mixing. We calculated chemical time and compared it with the vertical mixing timescale to find the quenched curve. We use our quenched curve data for various thermal profiles with varying internal temperature (T_{int}) and equilibrium temperature (T_{equi}) to see the effect of the quenched abundance of HCN and NH_3. We found an optimal value in the Eddy diffusion coefficient to maximize the quenched HCN for a given T_{int} and T_{equi}. We used the dataset of quenched abundances to provide a list of potential candidates in which HCN observation can be possible.

doi : https://doi.org/10.3847/1538-4357/acfc49

(Vikas Soni and Kinsuk Acharyya)

Formation of sodium-bearing species in the interstellar medium

The astonishing diversity of the molecular enrichment is found in star-forming regions. The advent of new state-of-the-art observational facilities and a significant increase in the capability of detecting molecules allows to study the formation of molecules of the less abundant elements. Sodium is one such element having an elemental abundance of $\sim 10^{-8}$ with respect to hydrogen. The observation of sodium-bearing species is not widespread in astrophysical objects, although NaCl and NaCN have occasionally been observed in assorted high-temperature regions. NaCl, known as table salt, is also found in planets such as Mars and Europa. We studied the formation of Na-bearing species, emphasising NaCl via gas-phase and grain-surface chemistry under assorted interstellar conditions. We ran two classes of numerical simulations: models under isothermal conditions at temperatures from 10 to 800 K with varied intervals and three-phase warm-up models that consist of an initial isothermal collapse at 10 K, followed by a warm-up phase in which temperature rises linearly to 200 K and then a hot core phase at 200 K. For both classes of models, we ran simulations with a range of values for reactive desorption efficiency for a two-atom formation mechanism to produce gaseous NaCl and NaH. We found that for isothermal models over a broad parameter space, the fractional abundances of gaseous NaCl and NaOH can be above 1×10^{-10} and 8×10^{-11}, respectively (which are in the detection range of observational facilities like ALMA and JWST). For warm-up models, we found that if we consider molecules co-desorbed with water, NaCl can have a sufficiently large abundance for detection to be possible.

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The work was carried out in collaboration with David E. Woon and Eric Herbst.

(Kinsuk Acharyya)

Remote Sensing and Data Analysis

Potential landing sites characterization on lunar south pole: De-Gerlache to Shackleton ridge region

The forthcoming LUPEX mission, a collaborative endeavor between ISRO and JAXA, aims to explore the lunar poles by deploying a lander and rover to the lunar south pole, with the primary objective of investigating volatiles. To achieve this goal, we extensively evaluated the feasibility of landing in four distinct locations (S, C1, C2, and D), each offering nearly continuous solar exposure.

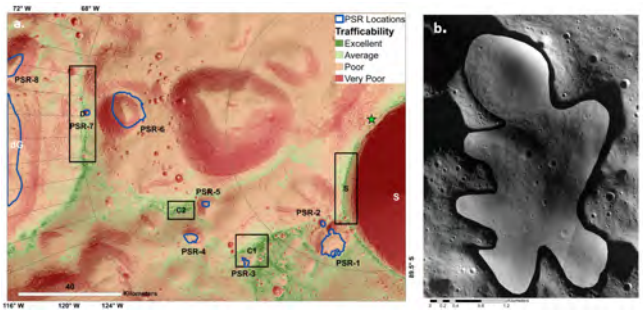

Figure 6: (a) Trafficability map for detecting suitable regions for landing and traversing on lunar south pole region between de-Gerlache to Shackleton. (b) Proposed traverse map for rover for site C1.

These sites, situated within one degree of latitude of the lunar South Pole, are delineated by two prominent craters, Shackleton

and de Gerlache, and exhibit diverse geological and topographical features. Our assessment of these locations considered various factors crucial for safe landing, including consistent solar power, terrain slope, illumination, surface roughness, temperature, accessibility to neighboring permanently shadowed regions (PSRs), compositional diversity, and navigability (Figure 6(a)). Each factor was assigned a specific weight, enabling us to rank the sites and determine their priority for exploration. The detailed analysis of landing sites suggests that site C1 is the most suitable option for landing. Aided by its high elevation, site C1 can offer a constant line of sight with rover as the landing point is marked at the highest elevated location. Its proximity to a micro PSR (Figure 6(b)), presence of scarps, and OH/H_2O-rich mineralogy with hematite deposits in the 500 m vicinity advocate this site to be scientifically enriched for exploration.

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This work was carried out in collaboration with C. D. Monalisa, Onshore Construction Company, Mumbai; Dr. P. Gläser, TU Berlin; Dr. Shyama Narendranath, U R Rao Satellite centre, Bangalore and Dr. K. S. Sajinkumar, University of Kerala

(S. Sathyan, M. Bhatt, D. Misra, N. Srivastava and A. Bharadwaj)

Contextual Characterization Study of Chandrayaan-3 Primary Landing Site

We have reported the contextual characterization of the primary landing site (PLS) of the Vikram Lander of ISROs Chandrayaan-3 mission (Figure 7). Vikram Lander successfully landed at this site (69.367621°S, 32.348126°E) on 23 August 2023 at 6:04 PM IST. The characterization was in the context of geomorphology, composition and thermophysical aspects using the best-ever high-resolution datasets. In this paper, we presented a detailed contextual investigation of the Chandrayaan-3 mission primary landing site in terms of identification, geomorphological, compositional and thermophysical context of the landing site. Using the best-ever high-resolution OHRC DEMs and Ortho-images, PLS has been fully characterized for terrain undulations, slope, aspect and illumination. Our geomorphological study based on the best spatial resolution data of recent times from OHRC indicate that the PLS is safe for landing and for rover operation. The geomorphological study indicates that the PLS is safe for landing with slope less than 4° in about 78% of the landing area and an average elevation variation of about 169m. The spectral analysis of the PLS region in visible - near-infrared wavelength region suggest that the region must have experienced extensive space weathering and represent typical highland type of soil characteristics. Compositional analysis indicate that the landing region has a typical highland type of soil characteristics with Mg (4.3 to 5.2 wt.%), Fe(4.2 to 4.9 wt.%), Ca(10-11 wt.%), and Ti(0.25-0.35wt.%). The PLS is dominated by meter-scale secondary craters, which are mainly responsible for regolith churning and do not excavate materials from deeper crust/mantle. However, as the lunar regolith formation and evolution is a complex process in which the smaller craters remix and redistribute the existing regolith layer, it will be interesting to map local scale compositional variations using APXS. The effect of solar and cosmic particles dominates the regolith upper layer and increases with the maturity of the surface. A detailed thermophysical analysis of PLS revealed a significant diurnal and spatial variability of ∼30K and ∼175K in spatial and diurnal temperatures at the PLS. This directs towards a local terrain of distinctive thermophysical characteristics within the landing region. Thus, the primary landing site at any given point will influence the thermophysical measurements and is expected to be greatly different from the surrounding areas. Significant variation of thermal inertia or the thickness of the outermost layer as seen around the PLS landing area could largely affect the thermophysical behaviour of the surface and subsurface. The outcomes of our spectral study will be a guiding point for APXS and LIBS onboard Chandrayaan-3 rover which will mainly look at local scale compositional and mineralogical differences. It is necessary to understand the stability of regolith-bound water-ice at the surface/shallow subsurface, which is an essential aspect for future lunar in situ resource utilisation studies. In situ data from the ChaSTE experiment will be able to provide validation and further understanding towards this. With important science instruments onboard and being the first-ever high latitude measurement, Chandrayaan-3 is definitely going to open up new vistas in the understanding of lunar science.

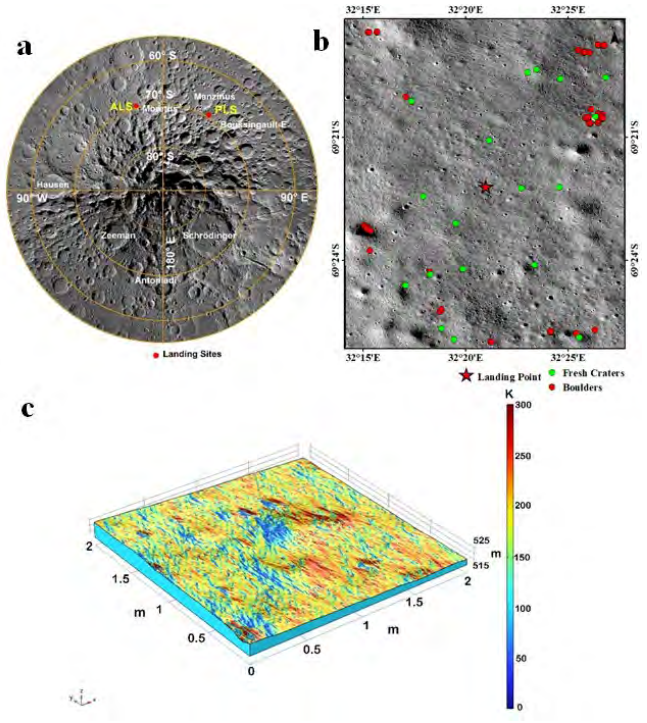

Figure 7: (a) Selected sites - Primary Landing Site (PLS) and Alternate Landing Site (ALS). Images used are taken from WAC of LRO. (b) Potential sampling sites in the form of fresh craters (green) and boulders (red) were observed around the probable primary landing side (blue) of Chandrayaan-3. (c) The model derived local scale surface temperature variation within 200m x 200m area at the center of the landing site, during the dawn phase, depicting distinct thermophysical behaviour at the local scale

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This work was carried out in collaboration with Amitabh from SAC Ahmedabad.

(K. Durga Prasad, Megha Bhatt, G. Ambily, Sachana Sathyan, Dibyendu Misra, Neeraj Srivastava and Anil Bhardwaj)

Discovery of Late phase volcanism in Australe North, possibly the oldest Impact Basin on the Moon

Australe North (35.5°S, 96°E) is a ∼ 880 km wide impact basin possibly older than the South Pole Aitken Basin (∼ 4.2 - 4.3 Ga) on the Moon (Figure 8). It is a highly obliterated structure and lacks a clear development of prominent topographic rings associated with impact basins on the Moon. Geological and geomorphological evidence of the existence of the ring of the Australe North Basin that earlier could only be seen using GRAIL (Gravity Recovery and Interior Laboratory) data. The Scaliger Crater (27.1°S, 108.9°E) region in the northeastern flank of the basin has been studied in detail to understand the influence of large basins on the local geology of the Moon. The Australe North Basin is revealed to be responsible for the magmatism in the area including late-stage volcanism lasting until ∼1.7 Ga in Bowditch Crater and exposing higher Mg# olivine-bearing rock assemblages at the Scaliger Crater central peak. The study demonstrates the presence of prolonged volcanism in the oldest basins away from the KREEP and how local geological evidence on a finer scale can be used to identify older impact structures, thus aiding the reconstruction of the lunar impact history.

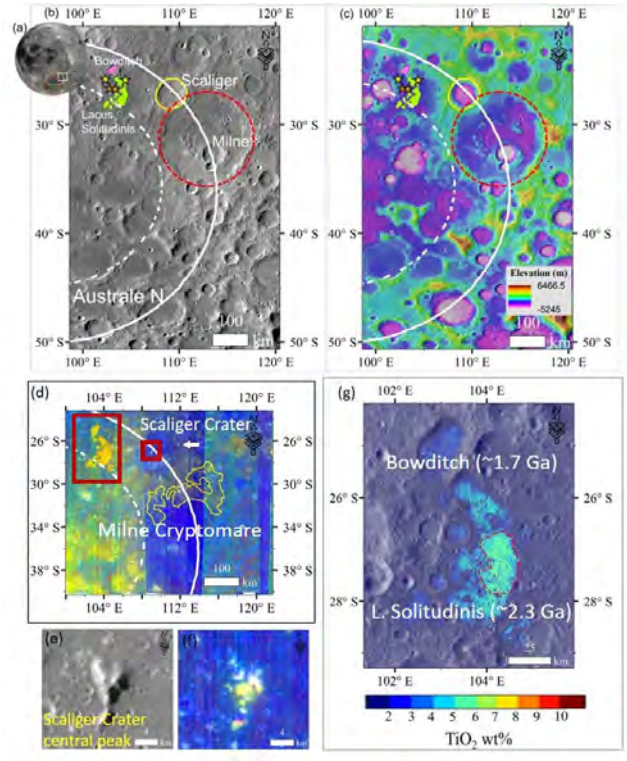

Figure 8: Mineralogy and chronology of the Scaliger Crater Region. (a, b) Geological setting, (c) Topography, and (d) IBD based False Colour Composite of the Scaliger Crater Region. (e, f) The zoomed-in images of the Scaliger Crater central peak highlight its mafic nature. (g) The TiO_2 wt% image depicts the late-stage volcanic unit in the region emplaced inside Bowditch Crater and Lacus Solitudinis at ∼1.7 Ga and ∼2.3 Ga, respectively.

doi : https://doi.org/10.1016/j.icarus.2023.115841

(Neha Panwar and Neeraj Srivastava)

Geologic investigation of the lobate scarps in the vicinity of Chandrayaan-3 landing site in the southern high latitudes of the moon

The primary landing site (PLS) of Chandrayaan-3 mission is situated in the southern high-latitude region of the Moon, between 68-70°S and 31-33°E. In this area, we have identified two scarps: scarp #1 and scarp #2 (Figure 9). These scarps are of particular interest due to their proximity to the PLS and the recent seismic activity associated with lobate scarps, which are among the youngest tectonic features on the Moon. Scarp #2 exhibits typical characteristics of a lobate thrust fault scarp, showing similarities in vergence direction, maximum relief, and maximum slope on the scarp face to scarps found elsewhere on the Moon. In contrast, scarp #1 appears to be potentially unrelated to faulting. Age estimates derived from crater size-frequency distribution (CSFD) analysis suggest that scarp #2 is a younger generation scarp, estimated to be around 20-30 million years old. Our detailed investigation has also revealed the presence of both fresh and faded boulder-fall trails on the rims and walls of several craters surrounding scarp #2. Seismic measurements indicate that the lobate scarp #2 could have induced a moonquake with a cumulative or maximum possible moment magnitude of Mw 6.3. However, based on our analysis of the potential ground shaking caused by this shallow moonquake, it appears that the landing site is not at risk from seismic hazards. We anticipate that the Instrument for Lunar Seismic Activity (ILSA) onboard the Chandrayaan-3 lander may be able to detect shallow moonquakes with a magnitude of Mw 4, provided that they occur at a focal depth of less than 1 km.

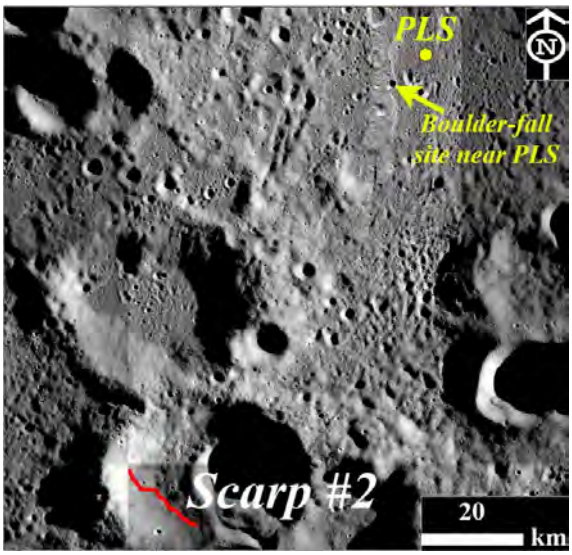

Figure 9: The newly discovered scarp #2 is located ∼78 km southwest of the Primary Landing Site (PLS) of the Chandrayaan-3 mission. A ∼1.8 km diameter crater with fresh boulder-fall tracks is found at a distance of ∼8 km from the PLS.

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This work was carried out in collaboration with Trishit Ruj, Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency, Sagamihara, Japan.

(Rishitosh K. Sinha, Alka Rani and Anil Bhardwaj)

Subsurface study of the Tharsis graben system using SHARAD data

Martian crust has an extensive graben system that covers a region more than 8,000 km in diameter and nearly one-third of the planet's circumference. Many of them trend radially outward from the Tharsis Montes. They are long-lived crucial features to determining the evolution of the tectonic and volcanic history of Mars. These thousands of grabens were discovered in the early 1970s and have been studied extensively with different hypotheses about their formation throughout the literature. These hypotheses include the formation process being either tectonic or a combination of tectonic and magmatic processes, however, no consensus has been reached so far. In this study, for the first time, we explore the subsurface of narrow graben systems using SHARAD data to understand and support the formation hypothesis of the martian graben system. We found multiple subsurface reflections in a narrow range of time delay at the rim of Mangala Fossa and at the floor of Labeatis Fossa (Figure 10). The loss tangent of the subsurface unit is in the range of 0.009 to 0.03, consistent with the low to moderate-density basalt. The presence of a basaltic subsurface unit at these locations confirms that magmatism was involved during the formation process of these two graben systems.

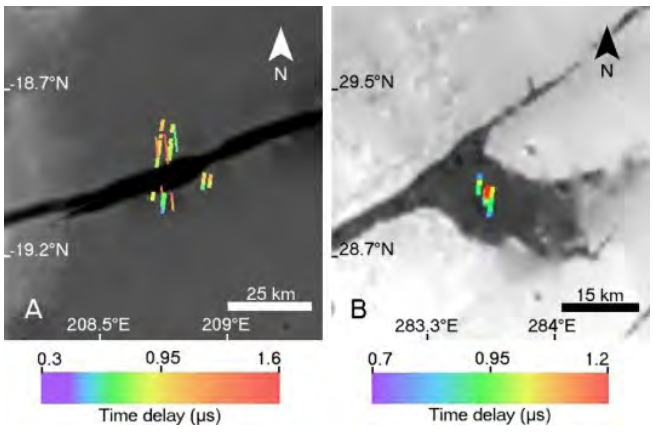

Figure 10: SHARAD subsurface reflection distribution map of the study regions laid over HRSC and MOLA Blended Digital Elevation Model at 200 m data (Fergason et al., 2018). (a) Mangala Fossa and (b) Labeatis Fossa. SHARAD ground track colors illustrate the two-way time delay of the reflections over the region.

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This work was carried out in collaboration with Isaac Smith, Planetary Science Institute, Lakewood, CO, USA and Shital H Shukla, Gujarat University, Ahmedabad

(Rajiv Ranjan Bharti)

Evolutionary history of western Eos Chaos of Valles Marineris, Mars: Insights from morphological characteristics

The dynamics of aqueous processes within the Eos Chasma region, located in the trough of Valles Marineris on Mars, have been linked to various Hesperian-aged landforms. Our research focuses on enhancing the understanding of the geological characteristics of the western segment of Eos Chaos by examining its morphological, topographical, and thermo-physical features. Our findings indicate that the western Eos Chaos features remnants of an elevated crater rim, a central peak, and a circular boundary, suggesting that it was once an ancient, highly degraded impact crater. Geological processes such as fluvial, tectonic, and aeolian activities have contributed to the shaping of these landforms. For example, channels on the slope of the wall with a mean v-index of 0.2 suggest a fluvial origin for some features. The chaotic mounds within the study area are extensively degraded. However, the presence of eroded inselberg peaks above the maximum ponding level of eastern Valles Marineris (-3560 m) indicates that both aeolian and fluvial processes have played roles in the erosion of the impact crater. Additionally, both aeolian and fluvial processes have influenced the morphological evolution of inselbergs in this impact crater within Eos Chaos. The morphological, topographic, and thermal inertia characteristics of the landforms in Eos Chaos are comparable to those found elsewhere in Valles Marineris. We consider the impact crater of Eos Chaos as a sub-region of Valles Marineris, where evidence of various past geological processes is preserved. Using possible chronological markers, we have developed a model to explain the evolution of the Eos Chaos impact crater and its integration into Valles Marineris.

doi : https://doi.org/10.1016/j.geogeo.2023.100207

This work was carried out in collaboration with Asif Iqbal Kakkassery, Government College Kasaragod; V. J. Rajesh, IIST, Trivandrum; Devika Padmakumar and K. S. Sajinkumar, Kerala Umiversity, Trivandrum.

(Rishitosh K. Sinha)

Meteorite, Analogue and Laboratory Studies

The Diyodar meteorite fall in India

Rantila (earlier known as Diyodar) is a rare, unique specimen of Aubrite meteorite (Figure 11) that fell at Rantila and Ravel villages of Diyodar Taluka, Banaskantha district, Gujarat on 17th August, 2022. So far, more than 450 stony meteorite falls are reported in the Indian subcontinent. Despite that, Rantila is the second reported aubrite fall in India, after Bustee (fall in 1852 at Gorakhpur, Uttar Pradesh). This rare specimen of meteorite not only improves the existing Meteoritic database, but the meteorite is also important for understanding the planetary processes in our solar system.

Figure 11: Rantila meteorite as recovered by PRL researchers during visit to Diyodar, Gujarat

doi : https://www.currentscience.ac.in/show.issue.php?volume=124&issue=02

(Srivastava, Y., Kumar, A., Basu Sarbadhikari, A., Ray, D., Nair, V.M., Das, A., Shukla, A.D., Sathiyaseelan, S., Ramachandran, R., Sivaraman, B., Vijayan, S., Panwar, N., Verma, A.J., Srivastava, N., Rani, A., Arora, G., Mahajan, R.R., and Bhardwaj, A.)

Meteorite fall in Bhojade village, Kopargaon taluk, Ahmednagar district, Maharashtra, India

Meteorite fall is a rare celestial event which provides an important clue about the origin and evolution of the Solar system. Kopargaon taluka of Ahmednagar district, Maharashtra witnessed a fresh meteorite fall on January 24, 2023, at 06:30 IST, the most recent fall in India (Met. Bulletin Database). In total, around a kilogram of the total meteoritic material was recovered. The meteorite pierced through the roof of a resident and fragmented after the fall on the floor. The preliminary investigation and laboratory studies argued for a monomict, fragmental breccia sample (Figure 12). Petrologically, the meteorite can be classified as LL 5 type. The remarkable similarity of Kopargaon chondrite with the S-type asteroid family suggested a possible link between the meteorite and asteroids.

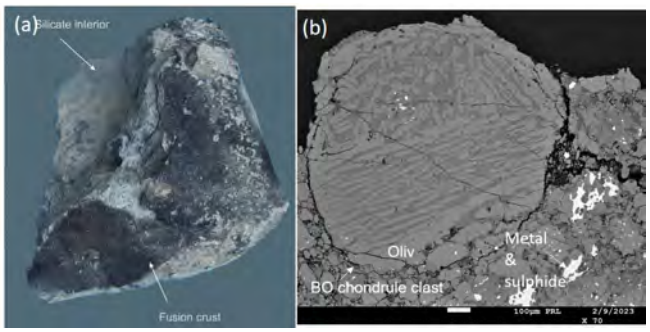

Figure 12: (a) Hand Specimen of Kopargaon chondrite (LL5), (b) BSE image of Barred Olivine (BO) chondrule clast

doi : https://www.currentscience.ac.in/show.issue.php?volume=124&issue=10

(D. Ray, A. D. Shukla and A. Bhardwaj)

Nitrogen isotopic signature in the ordinary chondrites

Nitrogen carriers in the inner protoplanetary disk play a major role in determining their incorporation into the planetesimals and its delivery to forming terrestrial planets. The nitrogen isotopic composition in solar wind is light while the cometary reservoir indicates heavier composition. The nitrogen composition of the solar nebula is probed using the meteorites of ordinary types. The majority of meteorites falling over the earth are ordinary chondrites. Based on their metal content, ordinary chondrites are further classified into three subgroups. Bulk samples of ordinary chondrites from Indian falls, Mahadevpur, Jodiya, Jalangi, Devri-Khera, Katol, Didwana-Rajod, Itawa Bhopji, Kaprada and other meteorites were analysed for their Nitrogen isotopic signature. Ordinary chondrites are classified into petrologic types based on their mineralogical and chemical properties. The data for bulk samples of ordinary chondrites indicate ^{15}N enriched component in them compared to that of solar wind. It is observed from Figure 13 that, there is no apparent relationship between the trapped nitrogen isotopic signature with the petrologic grade of ordinary chondrites. Lower grade meteorites have more variable nitrogen content, as they have a higher volatile content and they preserve their heterogeneity compared to the meteorites of higher grade. Intra-meteorite heterogeneity is observed in the meteorite analysed. The main reason for heterogeneity could be due to the presence of multiple nitrogen carriers with different isotopic signatures. Based on the nitrogen isotopic composition, it is proposed that the ordinary chondrites were formed around 2.5 AU distance from the Sun during the early solar system.

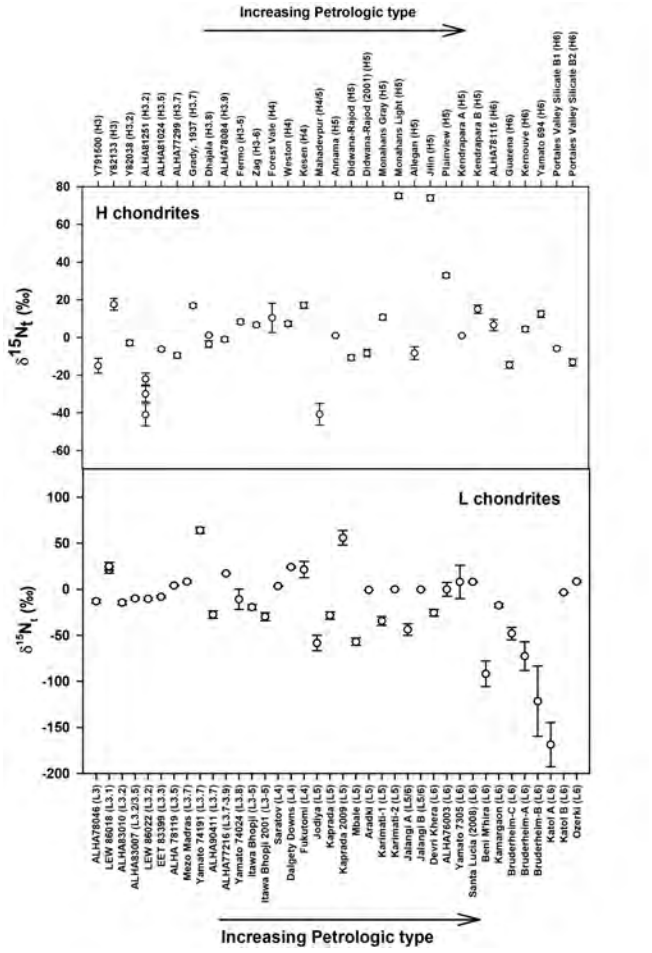

Figure 13: Trapped nitrogen isotope composition with the petrologic grade for ordinary chondrites

doi : https://doi.org/10.1007/s10509-023-04260-9

(R. R. Mahajan)

Noble gas and nitrogen investigation in two ordinary chondrites Zag and ALH 77216

The Zag (H type) and ALH 77216 (L type) meteorites are unique as they show solar-type neon isotopic composition. The analysis of these meteorites shows that the isotopic ratios of trapped krypton and xenon are of primordial type as compared to solar-type neon. Argon isotopes shows a mixture of solar-type and primordial composition. The concentration of trapped $^{20}Ne_t$ in the ALH 77216 are highest among all the ordinary chondrites. ALH 77216 also shows the highest concentration of ^{4}He, mainly of solar wind implanted.

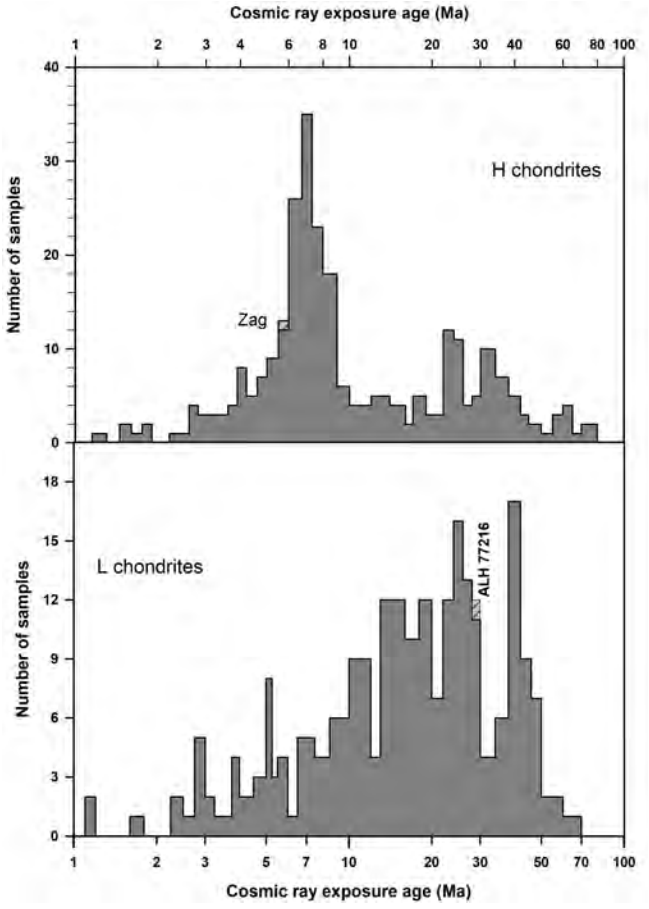

Figure 14: Cosmic ray exposure age of Zag falls and ALH 77216 meteorites

Concentrations of trapped ^{84}Kr and ^{132}Xe in ALH 77216 is within the range of ordinary chondrites. The elemental ratios $^{36}Ar/^{84}Kr/^{132}Xe$ in ALH 77216 plot along Q-SW mixing line, confirming the presence of solar-type argon in the meteorite. The concentration of trapped noble gases in Zag is within the ordinary chondrites. ^{40}Ar is produced from the decay of ^{40}K present in the sample. The concentration of radiogenic produce ^{40}Ar is unequally distributed in the meteorite Zag. Excess ^{129}Xe, which is a decay product of short-lived isotope ^{129}I, in a bulk aliquot of Zag is less than the matrix separates. The cosmic ray exposure age, calculated using cosmogenic isotope $^{21}Ne_c$ is 5.64 Ma and 28.5 Ma for Zag and ALH 77216, respectively. The cosmic ray exposure age of Zag falls on the major peak in H-type chondrites, while ALH 77216 falls on the major peak of L-type chondrites (Figure 14). Therefore, the two meteorites were ejected in major impact events occurred on their respective parent objects. The release pattern of nitrogen in two aliquots of Zag are not identical, and shows a mixture of heavy-light pattern, confirming the presence of multiple N components. The disagreement between the measurements of ALH 77216 indicates the presence of inhomogeneity of trapped N in the meteorite. Both meteorites do not show solar type N signatures. Distinct N isotopic signature in the solar wind type noble gas enriched meteorites are enigmatic.

doi : https://doi.org/10.1016/j.polar.2023.100966

(R. R. Mahajan)

Chondrules, metal separates and different lithologies of Indian chondrite Itawa Bhopji

Itawa Bhopji is an L type ordinary chondrite, fell in Rajasthan state of India on 30 May 2000. Bulk aliquots, metal separates and chondrules from this chondrite were analysed for the isotope ratios of noble gases and nitrogen on the noble gas mass spectrometer. Chondrules are spherical size and are major constituents of the chondrites, the first solids to have formed in the solar nebula. Chondrules from the Itawa Bhopji were studied for the isotopic composition of noble gases and nitrogen.

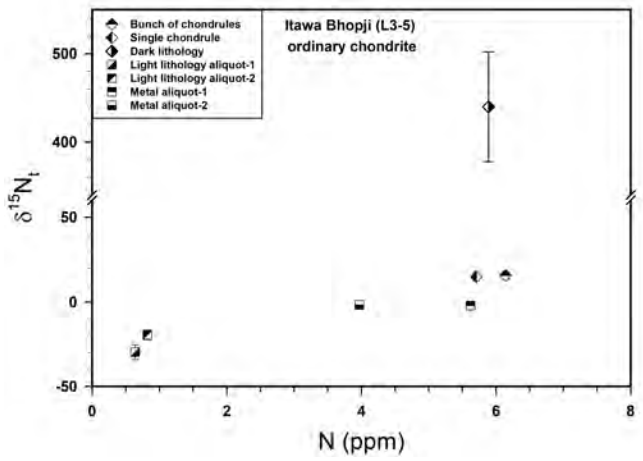

Figure 15: Nitrogen composition of various constituents of Itawa Bhopji chondrite

The concentration of trapped $^{20}Ne_t$ in chondrules is lower than the dark lithology sample, but higher than the light lithology. The concentration of trapped $^{36}Ar_t$ in chondrules is higher than the metal separates and comparable to the bulk aliquots. The trapped $^{84}Kr_t$ and $^{132}Xe_t$ concentration are within the range of bulk samples. Pre-compaction effects are not observed in the chondrules. Nitrogen isotope composition is diverse in various constituents of Itawa Bhopji chondrite (Figure 15). Nitrogen concentration of bulk aliquots is variable. The trapped nitrogen signature ($\delta^{15}N_t$) of chondrules is +15, distinguishable from that of solar wind, Q and pre-solar grains. Chondrules formed at the location in the nebula in which region the nitrogen isotopic composition was different from that of known early solar system reservoirs such as Sun, phase-Q and pre-solar grains.

This leads to the postulate that the heterogeneity in the solar nebula. Since chondrules formed in very short timescale after the onset of solar system formation, their formation location must be away from the Sun. The concentrations of noble gases vary in chondrules, metal separates and bulk samples of the Itawa Bhopji chondrite. This suggests that N component may not be associated with the noble gas component in this chondrite.

doi : https://doi.org/10.1016/j.pss.2024.105837

(R. R. Mahajan)

Tsunami or Storm? Mega-wave deposits on the southern tip of Eyre Peninsula, Whalers Way, South Australia

The presence of coastal boulder deposits on a calcreted bench 20 to 30 m above sea level, derived from the Cape Carnot Gneisses at the shoreline, suggests their emplacement by megawave activity. OSL dating of the sand body on the capping along with AAR dating of calcrete suggest that the event responsible for emplacement is younger than both the calcrete crust ($\sim$80 ka) and the sand body (17 ka). As the sea level during MIS 5e (17 ka) was $\sim$100 m below the present-day sea level, it is not likely that the coastal boulder field was deposited at this time. Furthermore, given the lack of weathering on the boulders we consider that the megawave event occurred after sea level reached close to its present position $\sim$7 ka ago, and most likely took place $\sim$4 ka ago when sea level was slightly higher than now. The mega-wave event is more likely to result from storm-wave activity rather than a tsunami event.

doi : https://doi.org/10.1080/08120099.2023.2272678

This work was carried out in collaboration with R. Bourman and C. Murray-Wallace from University of Wollongong, New South Wales, Australia.

(Dipak Kumar Panda and Debabrata Banerjee)

Comparative Analysis of Calcium-Aluminum Inclusions in Mukundpura CM2 and Murchison CM2 Chondrites

The Calcium-Aluminium Inclusions (CAIs) observed in the Mighei-like carbonaceous (CM) chondrites are small, porous aggregates. In CM chondrites, the central region of the unaltered CAIs primarily consists of melilite and spinel while the Wark-Lovering rims contain Aluminous diopside and anorthosites. During alteration, these refractory inclusions undergo secondary mineralization and form hydrous phases. Since CM chondrites are the most prevalent group of hydrated meteorites, investigating the alteration history of these chondrites is crucial. This study aims to understand the aqueous alteration of CAIs in CM chondrites through the mineralogical analysis of the Mukundpura (CM2) sample and compare the findings with that of the Murchison CM2 chondrite.

The backscattered electron image of the Mukundpura (CM2) sample reveals the presence of a subcircular-shaped CAI with a few dark patches in the interior, and a distinguishable rim around it (Figure 16). Geochemical analysis shows the presence of both unaltered and altered spinels. The altered spinels phases have low concentrations of Mg and Al along with Si, Fe, and S. Calcite is also found in the interior region. The rim region has Al and Ti-rich pyroxenes with FeO content reaching up to 6.7 wt%. The matrix region surrounding the CAI consists of phyllosilicates such as ferroan serpentines and cronstedite.

The CAI found in the Murchison chondrite shows the presence of hibonite. The other minerals found in this CAI includes spinel and diopside. A few areas consist of Fe and Si (FeO and SiO_2 content roughly 28 wt% and 36 wt% respectively) together with Mg, Ca and Al (MgO around 12.8 wt%, CaO and $Al_2 2O_3$ upto 9.1 wt% and 5.3 wt%, respectively). The CAI is surrounded by the phyllosilicate matrix consisting of cronstedite and ferroan serpentine.

The spinel-pyroxene inclusion observed in the Mukundpura has both pure spinels as well as some partially altered forms where Al has been replaced by Si, Fe, and S, indicating a process of secondary mineralization. The regions containing Fe and Si along with Ca, Mg and Al can be thought as the altered products arising from high calcium pyroxene where the primary elements are progressively replaced by Fe, indicating an alteration process. The CAI in the Mukundpura sample has undergone a greater degree of aqueous alteration than the Murchison sample. Calcite, located near the rim of the Mukundpura inclusion, is believed to have formed through aqueous alteration of the parent body, with carbonate precipitating from the fluid phase. These calcites could have originated from either high-calcium pyroxene or melilite. The phyllosilicates observed in the matrix regions of both chondrites are interpreted as products of aqueous alteration of the parent body.

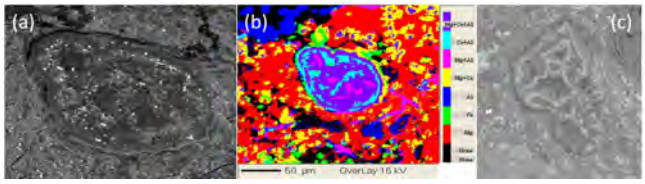

Figure 16: (a) BSE image of CAI in Mukundpura sample (b) X- ray map of CAI in Mukundpura sample (Ca, Mg, Al) (c) BSE image of CAI in Murchison sample

doi : https://www.hou.usra.edu/meetings/lpsc2024/technical_program/?session_no=725

(Anjana Shaju and Dipak Kumar Panda)

Characterization of the NaI (Tl) and $CeBr_3$ Scintillation detectors with Silicon photomultiplier (SiPM) readout

Hard X-ray spectrometers in the energy range of 20-300 keV are being developed at PRL for future planetary exploration missions. Detector modules with high detection efficiency and sub-millimeter pixel resolution are preferred. In this work, detector modules using Scintillation detectors coupled with an array of Silicon Photomultiplier (SiPM) are characterized. Scintillation detectors absorbs X-rays and generate optical photons as an output. The number of these photons

is proportional to the energy of the incident X-rays on the Scintillation detector. These output photons are read by the photon-detector and converted into the output current.

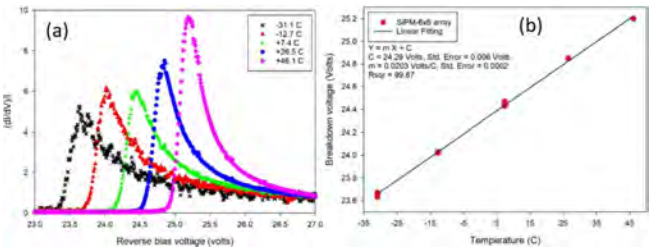

Figure 21: (a) Plots of (dI/dV)/I vs V to derive the breakdown voltage (Vbr) at different temperatures, (b) Dependence of Vbr on the temperature.

In this work, two types of inorganic Scintillators i.e. $CeBr_3$ and NaI (Tl), coupled with an array of SiPM are characterized for the future space exploration programs. Readout electronics has been developed for SiPMs current readout. The performance of the Scintillation detector and SiPM array is measured for various electronics parameters such as operating voltages of the SiPM, pulse shaping amplifiers time constant etc., where both $CeBr_3$ and NaI (Tl) are compared together. The behavior of the Scintillation and SiPM detectors under different ambient temperature conditions are also studied. Figure 21 shows the performance of the SiPM array under varying ambient temperatures. The breakdown voltage is derived to be dependent on the temperature with temperature dependence of +$\sim$20.3 mV/$^\circ$C.

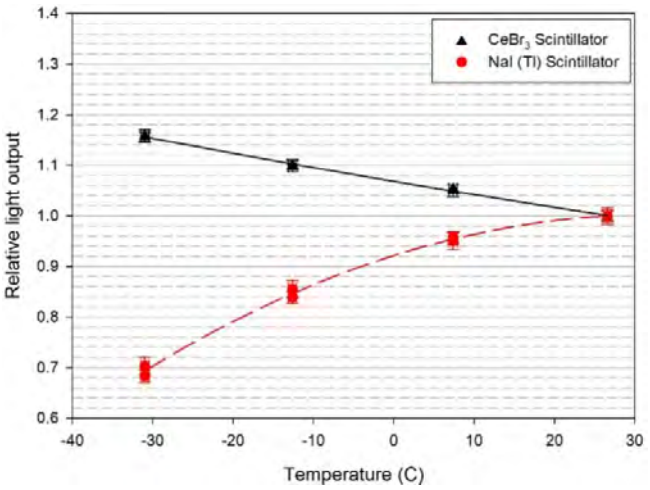

Figure 22: The variations of the output yield of Scintillation detectors with ambient temperature. The data are normalized with output at room temperature, i.e., 26°C operation.

The test results of both the Scintillation detectors show that performance (i.e. energy resolution) improves with higher over-voltage of SiPM and lower operating temperature. The gain of the SiPM array shows negative temperature dependence of $\sim$-0.81%/$^\circ$C for an over-voltage of 2.5 Volts. To derive the temperature dependency of scintillators output photons, the gain of the SiPM array was made constant by operating it at a fixed over-voltage for a wide temperature range. With the constant gain of the SiPM, the $CeBr_3$ scintillator shows negative temperature coefficient of $\sim$-0.27 %/$^\circ$C and NaI (Tl) shows a positive temperature coefficient of $\sim$+0.5 %/$^\circ$C for the light output in the temperature range of -31°C to +26°C as shown in Figure 22.

doi : https://doi.org/10.1016/j.asr.2024.01.053

(S. K. Goyal, A. P. Naik, P. Sharma, A. J. Verma, N. Chotaliya and M. M. Soni)

Developmental Work

Supra Thermal & Energetic Particle Spectrometer (STEPS) - onboard Aditya-L1 mission

STEPS is one of the independent subsystems of the Aditya Solar wind Particle EXperiment (ASPEX) onboard Aditya-L1 mission, which is placed in L1 point of the Earth-Sun system. STEPS covers the high-energy spectrum of the particles in the range of 20 keV/n to 5 MeV/n from six directions, i.e., Sun-Radial (SR), Parker Spiral (PS), Earth Pointing (EP), Intermediate to SR and PS (IM), and North (NP) & South (SP) of the Sun-Earth ecliptic plane. The STEPS subsystem has been configured into three packages in order to cover the six directional measurements i.e. STEPS-1, STEPS-2A and STEPS-2B. STEPS-1 package houses four detector units (SR, IM, PS and NP) and their front-end electronics (FEE). STEPS-2A package has one detector unit (EP) and FEE for EP and SP (STEPS-2B) detector units. ASPEX-PE is a processing electronics package, shared between SWIS and STEPS.

Flight models of the STEPS were delivered to the Aditya-L1 project. After carrying out the first interface tests with the spacecraft, STEPS mounting was cleared for assembly. Multiple tests were carried out at URSC - Bangalore, during different stages such as: dis-assembled mode test - without any other payload; dis-assembled mode tests with all payloads; assembled mode tests without powering ON other payloads and at last assembled mode tests with all payloads simultaneously ON. The various T&E tests of the STEPS with Spacecraft were carried out including long-duration thermo-vac tests, and dynamic and acoustic tests at ISITE - Bangalore. The spacecraft was then moved to SDSC - SHAR for the final assembly with the PSLV.

Aditya-L1 was launched on 2^{nd} September, 2023. For the STEPS operation: different operating commands / macros were finalized in discussion with the mission team. STEPS payload was powered ON during its Earth-bound orbit (EBN-3), on 10^{th} September 2023, when the altitude was greater than 8 R_E (>52,000 km). All the units were switched ON and performance, and housekeeping parameters were verified. The data were quickly analyzed in the Quick Look Display (QLD) software, installed at ISTRAC - Bangalore, as shown in Figure 17. Figure 18 shows the light curve for the NP detector unit, in terms of the integrated counts, acquired on 10 September 2023. STEPS has measured high-energy particles in the Earth-bound phase as well as during the cruise phase to the L1 orbit. Aditya - L1 spacecraft was inserted into Sun - Earth L1 halo orbit on 6 January - 2024. STEPS data is being processed from Level - 0 to Level - 1. Level - 1 data provides direction wise spectrum in terms of the counts with ADC channel numbers. The processing of the Level - 1 to Level - 2 is also being carried out which provides science data in CDF format. Level -

2 data is provided in terms of the flux i.e. particles / (cm^2-s-Sr-MeV) with time in UTC for multiple energy bands.

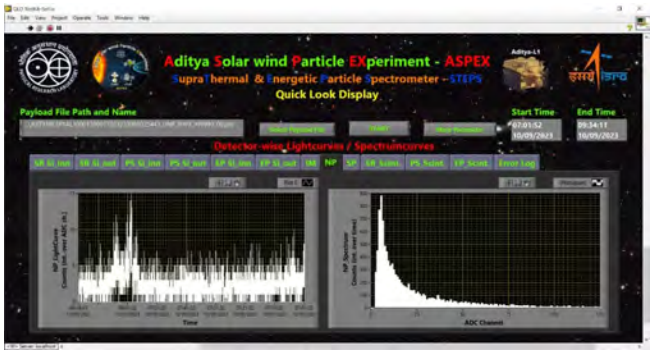

Figure 17: The data, acquired on 10/09/2023, for the NP detector unit, from 08:16 UT to 09.34 UT.

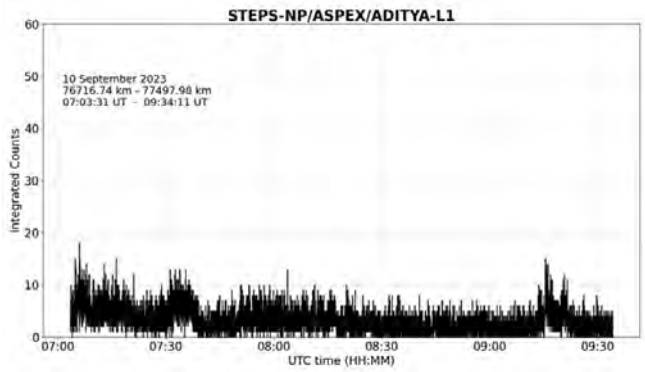

Figure 18: Time series of the integrated counts recorded by the NP unit of STEPS sensor of ASPEX payload on 10 September 2023.

(S. K. Goyal, D. Chakrabarty, S. Vadawale, M. Shanmugam, N. K. Tiwari, A. R. Patel, P. Sharma, J. Sebastian, A. Sarada, B. Dalal, T. Ladiya, A. Sarkar, A. Bhardwaj, P. Janardhan, A. J. Verma, S. Kumar, D. Painkra, N. Singh and ASPEX Team)

Neutral & Ion Mass Spectrometer for the study of planetary atmospheres

The development of a quadrupole mass spectrometer for the measurements of neutral species and ambient ions is being undertaken at PRL. This instrument, called as Neutral & Ion Mass Spectrometer (NIMS) is being developed for a mass range of 2 - 150 amu (M/ΔM $>$10) for future planetary missions. The objective of the payload is to carry out the in-situ measurements of neutral species and ambient ions to characterize the planetary upper atmosphere and ionosphere. Figure 19 shows the mechanical design and development perspective, after several design checks and iterations. This shows the NIMS assembly, having a modified design of parts like the quadrupole rods, voltage connection rods, alumina spacers, and shield tubes as per the requirements posed by the system electronics. A 3D CAD model of the mass-optimized shield tube is displayed along with the recently fabricated model of the same as per the design (Figure 19). Similarly, the design of other mechanical parts is ready and is in the finalization stage of fabrication.

The simulation of Electron Impact Ionization within the ionizer components of the Neutral and Ion Mass Spectrometer (NIMS) using SIMION software is crucial for optimizing instrument performance. By accurately modeling the various parts of the ionizer section (Repeller grid, thoria-coated iridium filament, anode grid, and focus grid), insights into ionization efficiency and optimization strategies are gained. Applying voltages of -58V and +12V to the Repeller and anode grids, respectively achieves a potential difference of 70V for ionization, with an additional focus voltage of -90V applied. The simulation methodology involves defining geometrical and electrical properties within SIMION, facilitating the analysis and optimization of ionization efficiency. The impact on ionization efficiency is examined by varying parameters such as electron energy, filament temperature, and grid potentials. Simulation results offer valuable insights into ionization dynamics, enabling the fine-tuning of parameters to maximize instrument sensitivity. The discussion denotes the influence of geometric factors and electron energy distribution on ionization dynamics, contributing to a comprehensive understanding of NIMS electron impact ionization mechanisms. Figure 20a shows the ionizer section and Figure 20b shows the simulation screen-shot of ion source.

Ion efficiency refers to the ratio of ions generated to the total number of neutral particles subjected to electron impact ionization. Through the simulation, factors influencing ion efficiency, such as grid potentials, filament temperature, and geometric configurations, are systematically explored. Optimization strategies are devised based on simulation results to maximize ion efficiency and enhance instrument performance.

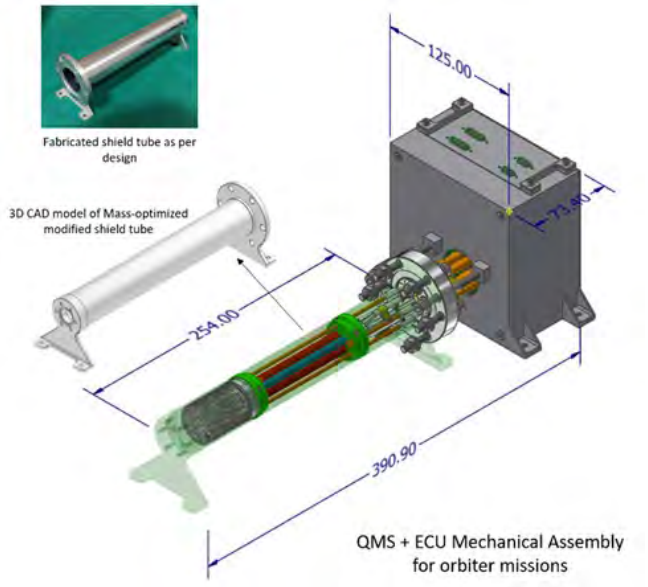

Figure 19: The mechanical design of NIMS

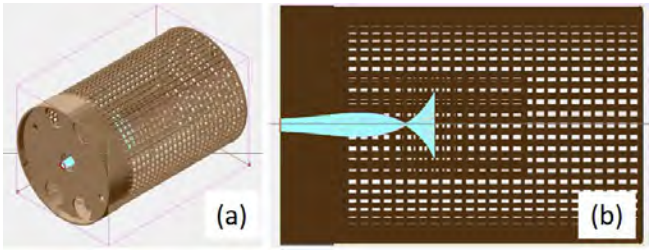

Figure 20: (a) Ionizer section design in SIMION software (3-D view), (b) Simulation results for the Ion source generated in anode grid (YZ plane).

(P. Sharma, A. J. Verma, N. Upadhyay, R. R. Mahajan, S. K. Goyal, Varun Sheel and NIMS team)

Dust EXperiment (DEX) on-board PSLV C-58 (XPoSAT mission)

Interplanetary Dust Particles (IDPs) from Asteroids and Comets have a dynamic evolution under different forces of nature. They can come in close proximity to planetary bodies and interact with them during this evolution. In the case of Earth-like planets, these particles get ablated in the atmosphere and release metallic ions, affecting the ionospheric layers. It is important to know the flux of IDPs entering the planet in order to understand the extent of this effect.

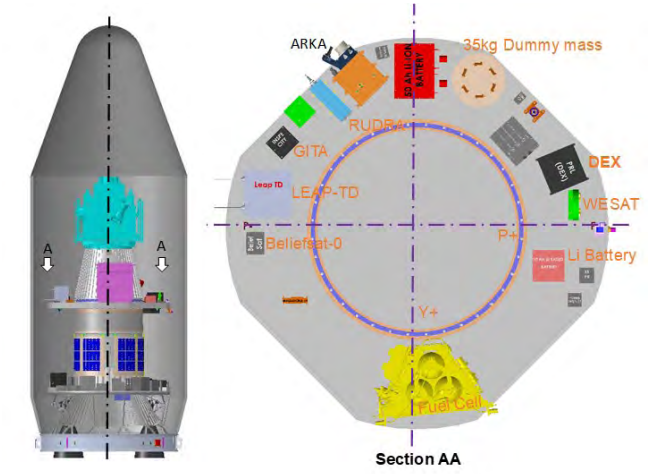

Figure 23: Position of DEX mounted on POEM-3, PSLV C-58, along with fellow payloads.

The Dust EXperiment (DEX) was flown on the PS4-Orbital Experimental Module (POEM) of PSLV C-58 (XPoSAT mission), launched on 1^{st} January, 2024. The POEM-3 had an equatorial orbit with an inclination of 9.5°. The DEX was developed to measure dust impacts during its observation period in the low Earth orbit. Figure 23 shows the position of DEX on POEM-3. Based on the received data, DEX has been found to be working successfully in space.

DEX is an impact ionization dust detector, where charge is generated on the impact of hypervelocity particle on the metal target. The charge is then collected by the voltage biased collector plates and further amplified and processed using electronics. The Electron Channel (EC) with positively biased plates collect the electrons and the Ion Channel (IC) with negatively biased plates collect the ions. A third Target Channel (TC) is connected to the detectors target. The analog chain of CSPA and buffer can be seen in Figure 24(a). Since, there are two collectors for each EC and IC, these signals are added using an adder in processing PCB (Figure 24(c)). The signal is then digitised using Analog to Digital Converter (ADC) and sent to FPGA for further processing.

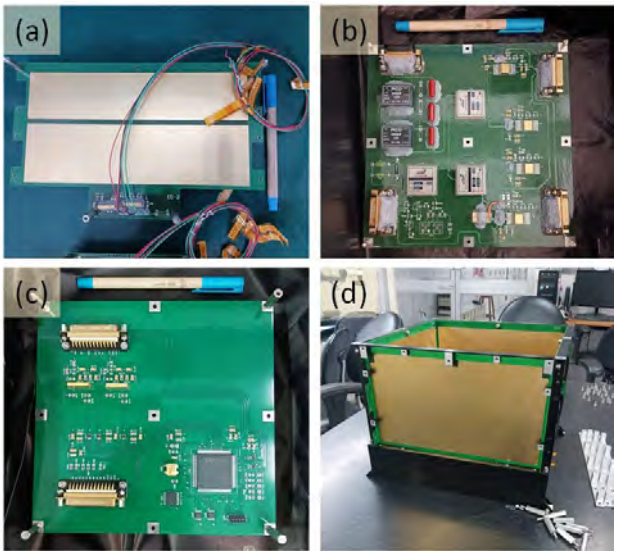

Figure 24: Cards of flight model with components soldered on them. (a) Housing PCB (b) Power card (c) Processing PCB and (d) Detector structure after mounting PCBs.

The FPGA is responsible for searching the signal in each 10 s interval and stores the data of 160 μs around the peak value. These data are then arranged in an appropriate frame format along with the required headers, which include the start byte, event number, time and an end byte as a footer. All the payloads on POEM are connected to a single RS485 bus. On prompt from the Data Processing Unit (DPU) of POEM, which is every 16 ms, the payload replies with two bytes of data as per RS485 protocol.

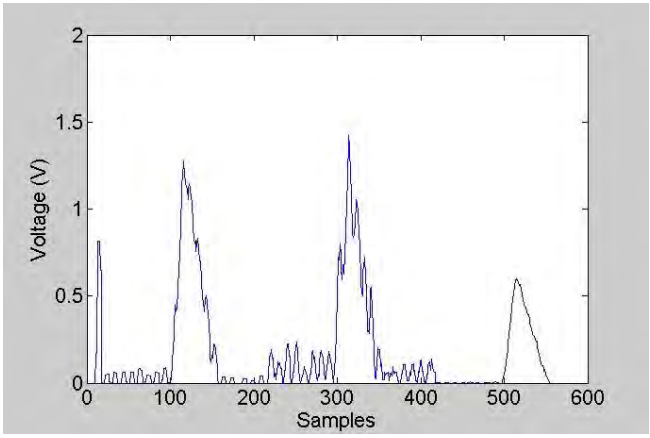

Figure 25: Typical output of DEX post processing during T&E

The data are downlinked during the period of visibility and sent to the payload team. Figure 25 shows a typical processed output data of DEX with a start byte and three-channel data. Here, the input was provided using a simulated pulse from the signal generator. The payload was tested as per the POEM requirement document (Report No: PSLV-VSSC-P-POEM-001-2023, Issue-1). The tests included the Burn-In test, sine and random vibration test, EMI-EMC test and thermo-vac test. Figure 26 shows DEX on shaker post harness routing for sine and random vibration test. DEX has provided observations for about two months at an altitude of ∼350 km in the equatorial orbit.

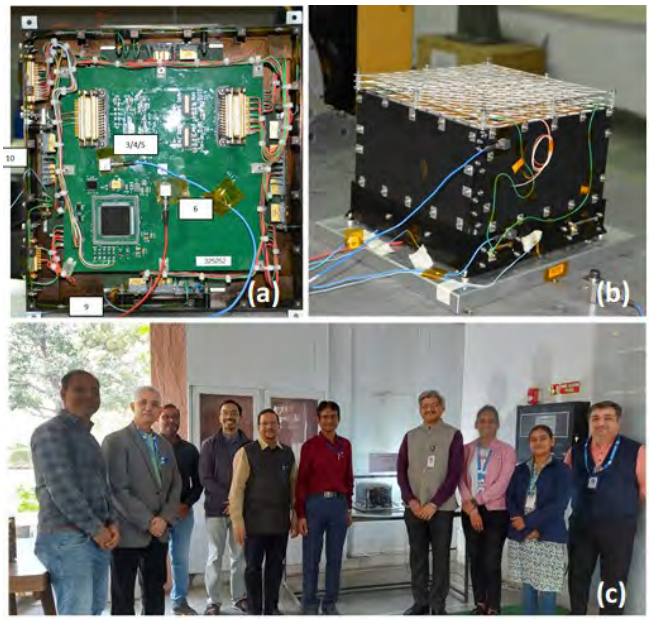

Figure 26: Flight model of DEX (a) During assembly (b) Under vibration test (c) During flag-off

(J. P. Pabari, S. Nambiar, Rashmi, S. Jitarwal, K. Acharyya, V. Sheel, R. Mahajan, Anil Bhardwaj and Team)

VODEX Development

Interplanetary Dust Particles (IDPs) evolve dynamically in the solar system and may be captured by a planet on its way. When passing through the atmosphere, such IDPs get ablated and leave metallic ions in the lower ionosphere. To understand the meteoroid layer in the electron density profile, it is essential to know the IDP flux, which is an important input to the ablation process. There are no measurements of IDP at and around Venus, except for a few measurements of IDP at larger distances from Venus. A Venus Orbit Dust Experiment (VODEX) is proposed for future Venus orbiters to study the mass, speed and flux of IDP at and around Venus, and also between Earth and Venus. As a part of the project, DEX was flown in PSLV C-58.

VODEX testing using pulse laser: A nanosecond pulse laser is utilised to simulate dust particle impact for a dust detector. The setup at Institute of Plasma Research (IPR) is utilised for this purpose, where a Nd-YAG laser source is employed. The laser is to be run in single-shot mode to simulate discrete dust particle impacts. Since, the operation energy is low, the single shot mode results in variation in laser energy from one shot to another. This is overcome by using an electronically controlled shutter, which is connected to a laser driver and a signal generator through a digital delay generator. A 100 ms pulse is generated using the signal generator, which, when matched with the laser driver pulse, leads to the opening of the shutter for the next pulse, considering the delay. An energy meter was kept in the path of the diverged beam; however, it was inefficient due to the low laser energy. Additionally, a photodiode was used to trigger the oscilloscope to record the measurement which functioned adequately for the most part with inconsistent triggers for some pulses, possibly due to non-fixture, in which case signal levels were used for triggering. The setup is shown in Figure 27. Further, since high-sensitivity CSPA was used inside the detector, the range of laser energy above the ablation threshold and below saturation became limited. Observations were taken within these limited ranges for different bias voltages of collector plates. Further work is underway.

A part of the work was carried out in collaboration with Dr. R. K. Singh, IPR, Bhat.

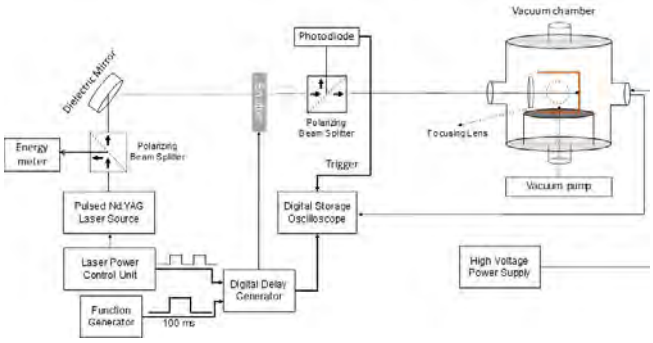

Figure 27: Pulse laser testing set up at IPR, Bhat

(J. P. Pabari, S. Nambiar, Rashmi, S. Jitarwal, K. Acharyya, V. Sheel, R. Mahajan, Anil Bhardwaj and Team)

Different Design Configurations for LIVE

A Lightning Instrument for VEnus (LIVE) is being developed at PRL for the detection of lightning on Venus. The development of the Engineering Model (EM) of LIVE has been initiated. Design options for the wide band filter vs. discrete frequency filters are compared based on specific requirements. Both design options are implemented in a single PCB as shown in Figure 28(c). Initially, the output voltage amplitude levels were checked for the known input level. The sine wave of 730 Hz frequency and 10 mV amplitude is applied as an input to both the design options and the responses obtained on the oscilloscope were analyzed. Different responses at the power line filter and pre-amplifier (pink colour), at the 730 Hz discrete frequency filter (green colour) and at the wide band filter (blue colour) are shown in Figure 28(b). To provide power to all the modules in the PCB, a power card PCB was also designed and tested for the required voltage levels as shown in Figure 28(d).

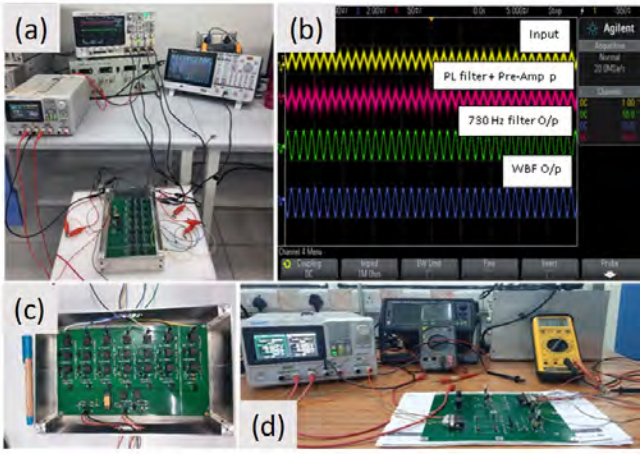

Figure 28: (a) Laboratory testing set-up of LIVE PCB (b) Testing results of different stages (c) LIVE PCB having both design configurations (d) Testing set up of power card module made up with commercial components.

We found that the amplitude of the time domain signal detected by both the design options is at the same voltage level i.e., 2 volts. Further, we performed the discrete Fourier transform of the captured signal using the Fast Fourier Transform (FFT) technique to see the frequency components present in the time domain signal as shown in Figure 29. In addition, we compared the Signal-to-Noise Ratio (SNR) in both cases, i.e., 26 dB and 20 dB for discrete and wide band filter simultaneously. We analyzed the performance of both design configurations to find the one, most suitable to detect lightning-generated electromagnetic waves in the Hz-kHz range. For this purpose, we used time and frequency domain information. Both design options were found to work equivalently. Further optimization is currently underway.

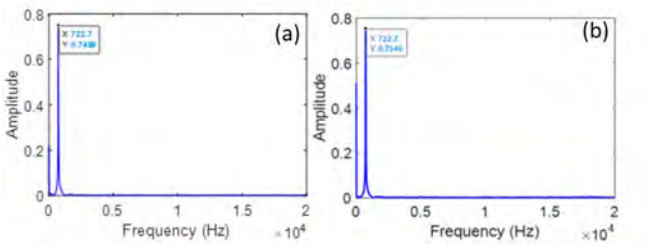

Figure 29: FFT of the captured time domain pulse (a) 730 Hz Filter response (b) Wide band filter response

(J. P. Pabari, S. Jitarwal, Rashmi, S. Nambiar, K. Acharyya, V. Sheel, Anil Bhardwaj and Team)

Planetary Environment Simulation Chamber for Experimental Simulation of Venusian Lightning

Lightning is a sudden electrical discharge of a very short duration in the order of a few tens of microseconds or so. In the case of the planetary atmosphere, lightning discharge occurs whenever the electric field exceeds the breakdown voltage. The lightning phenomenon is not fully understood in the case of Venus, therefore there is a need for an in-depth understanding of the discharge phenomenon occurring within the Venusian atmosphere.

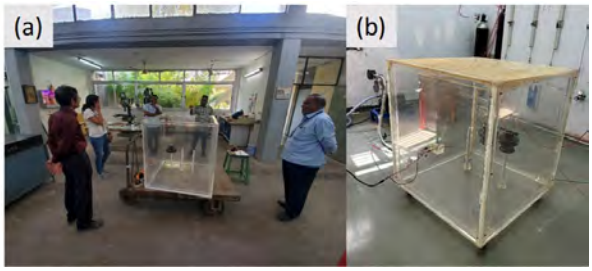

Figure 30: (a) Acrylic vacuum chamber at PRL workshop and (b) the testing set up for lightning discharge inside the chamber.

To simulate the Venusian environment, the vacuum chamber needs to be filled with various gases in proportions similar to the Venus atmosphere (i.e., 96.5% CO_2, 3.5% N_2 and 150 ppm SO_2). For this purpose, an acrylic made vacuum chamber having dimensions of 3' x 3' x 3' was designed and developed at the PRL workshop. It has four ports, one on each wall for inputs of HV electrodes and outputs of antenna terminals to connect to the oscilloscope for discharge pulse recording. For lightning spark generation, the HV electrodes kept inside the chamber are 10 cm apart. Using a 150 kV impulse generator facility at CHARUSAT, the 3 MV/m field was generated, sufficient for the breakdown of gases in the Venusian and Earth environments. To detect lightning-generated electromagnetic waves, a short dipole antenna was kept inside the chamber with different lengths of 10 cm, 15 cm and 25 cm. Further, a gas manifold system was set at CHARUSAT for mixing different gases and filling the chamber. Figure 30(a) shows a chamber for the simulation of lightning discharge in the Earth environment.

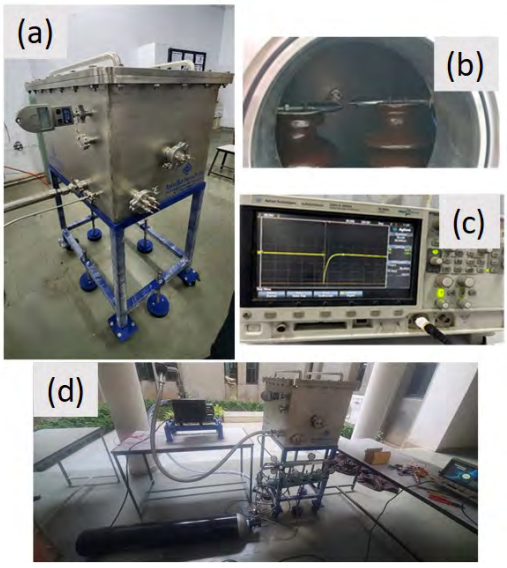

Figure 31: (a) SS chamber unit with different ports, (b) placement of HV electrodes inside the chamber, (c) lightning discharge pulse observed on oscilloscope during experiment (d) complete test set-up of steel chamber with gas manifold system, Pirani gauge and rotary pump.

To improve the vacuum performance of the system, a steel vacuum chamber was designed and fabricated at CHARUSAT for simulating Venus and Earth-like environments. The dimensions of the steel chamber were optimized and made to 725 mm in length, 500 mm in width and 540 mm in height. The pressure variation from 10 mbar to 1 bar has been achieved within the chamber, which represents the upper half of Venusian clouds, from where the lightning may be initiated. Figure 31 depicts the chamber with different ports, attached Pirani gauge and the gas manifold system. Further testing is ongoing with different gas mixing proportions using the gas manifold system attached to the chamber.

The work was carried out in collaboration with Prof. T. Upadhyaya and team, CHARUSAT, Changa.

(J. P. Pabari, R. Mahajan, S. Jitarwal, K. Acharyya and Team)

Development of a Package to Process Raw RO Data from Akatsuki

A complete package has been developed at PRL, to process the raw data, received at the Indian Deep Station Network (IDSN) from the Akatsuki Radio Science Experiment. The raw data is in binary format regarding In-Phase(I)/Quadra-Phase(Q) of the radio signal received by the IDSN. Doppler residuals to the Venus atmosphere have been calculated after correcting for the relative doppler and other effects. A sampling rate of 200KHz was used, and FFT and signal processing were performed. Subsequently, atmospheric profiles were retrieved using the basic concept of geometrical optics for the neutral atmosphere and ionosphere. The package is written in Python. Several corrections and testing were done to test the algorithm against published results.

(Varun Sheel)

ChaSTE Experiment onboard Chandrayaan-3 Vikram Lander successfully accomplishes the first-ever thermal measurements at a high latitude location on the Moon

The Moon's surface is subjected to extreme thermal environment. The information on temperature and thermal conductivity of Lunar surface regolith is the key parameter that decides the depth of solar forcing and the loss rate of volatiles including the water ice in the polar and near polar regions, particularly in the Sun-illuminated regions. Lunar temperatures at the sub-solar point approach 400 K at equatorial regions, whereas temperatures in permanently shadowed regions may be as low as 50K. On the other hand, high latitude and polar regions exhibit a completely distinct temperature variation and thermophysical behaviour. Most in-situ probing was conducted by Apollo missions in and around the Lunar equatorial region. No in-situ measurement is available from high-latitudes and polar regions of the Moon. To accomplish these, an experiment called Chandras Surface Thermophysical Experiment (ChaSTE) was flown onboard the Chandrayaan-3 Vikram lander. The key objective of the instrument is to investigate the temperature profile and thermophysical properties within the top 100 mm of the lunar surface at a high-latitude landing location. The ChaSTE payload consists of a thermal probe, an electronics module for data acquisition, processing and control and a mechanism for deployment and insertion of the probe into lunar regolith (Figure 32). The ChaSTE thermal probe consists of 10 temperature sensors (Platinum Resistance Temperature Detectors (RTDs)) mounted at different locations along the length of the probe to provide the thermal profile of the near-surface lunar soil at the landing location. A heater is also attached to the probe for thermal conductivity measurements. ChaSTE Probe was kept stowed during the entire flight, from launch till landing.

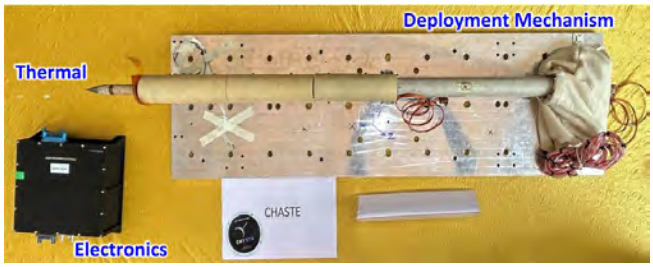

Figure 32: ChaSTE experiment with its various subsystems

Figure 33: PRL ChaSTE Team

ChaSTE experiment, jointly developed by PRL and SPL/VSSC, has been flown onboard Chandrayaan-3 lander and successfully operated on the surface of the Moon to provide the first-ever in-situ thermal measurements of a high latitude location of the Moon. In continuation to the delivery of CH3 ChaSTE FE to SPL/VSSC, Trivandrum for further activity, the PRL ChaSTE team has played a pivotal role in all pre-flight clean room activities both at ISITE, Bangalore and SDSC, SHAR, to verify the performance of the instrument and provide necessary inputs to the project at each stage. They have also participated in the launch and landing activities of Chandrayaan-3. Following the successful soft landing of Chandrayaan-3s Vikram lander at the designated location on the Moon, now called Shiv Shakti point, the ChaSTE probe was deployed and successfully penetrated in to the lunar soil to provide the first-ever in-situ thermal measurements at a lunar high latitude location. ChaSTE has carried out measurements for the entire operation of the mission and provided very interesting data that is currently under analysis. The members of the PRL ChaSTE team (Figure 33) have been at the mission control centre, ISTRAC, Bangalore during the entire duration of the operation of ChaSTE and the lander experiments, right from landing day till the lander was put to sleep. During this period, they carried out the first cut analysis of the data received, planned ChaSTE payload operations and coordinated with the mission control teams for ChaSTE activities. Detailed analysis of ChaSTE observations is ongoing. With first-ever

measurements of its kind, ChaSTE will definitely provide important insights into the parameters and processes prevailing at the high latitude location of the Moon thus enhancing our understanding of the Earths nearest neighbour.

(K. Durga Prasad, Chandan Kumar, Sanjeev Mishra, P. Kalyan S. Reddy, Janmejay Kumar, G. Ambily, Tinkal Ladiya, Arpit Patel, Anil Bhardwaj and ChaSTE Team, SPL/VSSC)

Development and design of quick look display and data processing algorithm for ChaSTE payload Flight data analysis

We have designed and developed a new Quick Look Display (QLD) and data analysis software for processing the raw and level 0 format files of ChaSTE Flight data. The Software was validated with the Lunar Transfer Orbit datasets and was finally used to analyse payload data after landing and payload operations. The QLD was made using PYQT5, and the processing software was written in Python using different libraries. The complete data were processed and analysed, and the data was accurate and met the calibration design targets. A screengrab of the developed software with a plot of the sample dataset is shown in Figure 34.

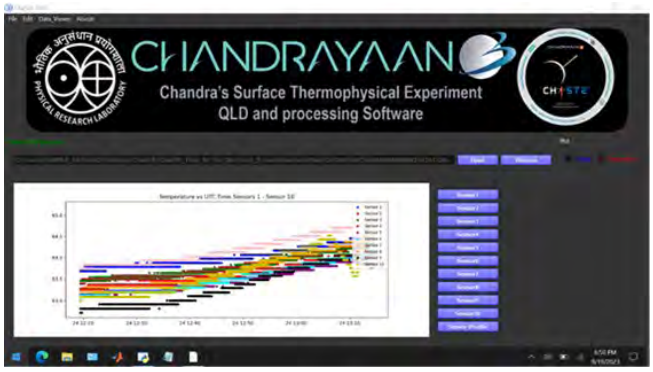

Figure 34: Snapshot of QLD software developed for CHaSTE

(Chandan Kumar and K. Durga Prasad)

Characterisation experiments for ChaSTE under simulated lunar environment

The Chandrayaan-3 lander successfully deployed the ChaSTE thermal probe into the lunar regolith and temperature profiles of the top 10 cm of the lunar regolith were obtained for several earth days. This gives the partial diurnal temperature variations inside the 10cm of the lunar surface at the Chandrayaan-3 landing site. The interpretation of the temperature data requires the estimation of the extent to which the measured temperatures were affected by the presence of the thermal probe. The ChaSTE thermal probe is made of a very low thermal conductivity material and its thermo-physical properties are quite different from those of the lunar regolith. We carried out the characterisation experiments inside the lunar environmental simulation chamber, developed indigenously at PRL, to assess the effect of probe material on the measured temperatures (Figure 35). In our characterization experiments, we have used the identical ChaSTE Thermal probe made from the same material as that of the flight model and populated with ten 4-wire RTDs. The lunar environment conditions, including the vacuum and temperatures, were recreated and controlled throughout the investigation. The surface stratigraphy was created using the Sittampundi Anorthosite of mixed grain sizes, a lunar soil simulant. The solar insolation conditions were simulated using a light source, and the intensity was adjusted to replicate the solar influx reaching the moons surface at the landing site. The thermal probe was placed inside the simulant surface to simulate the deployed conditions of the probe inside the lunar surface. Several experiments were conducted under the same temperature and pressure conditions to understand the probe's perturbation effects on the temperature profile. The data obtained from these characterization experiments will be used to interpret the insitu data obtained from ChaSTE.

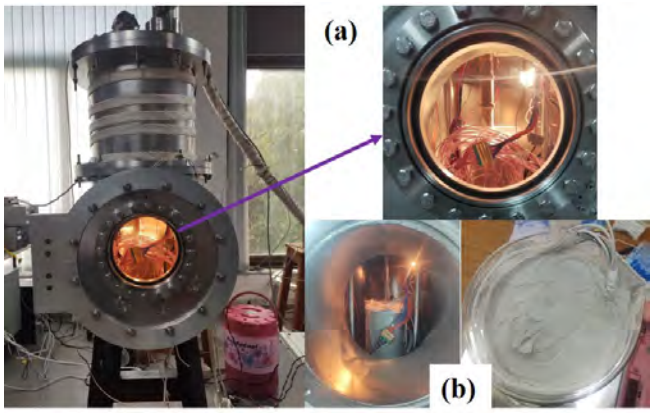

Figure 35: Lunar Simulation Chamber a) Experiments with the Probe in simulant, b) Setup for temperature profiles measured using RTDs alone.

(P. Kalyan S. Reddy, K. Durga Prasad, Chandan Kumar, Janmejay Kumar, Sanjeev Mishra and G. Ambily)

Alpha Particle X-ray Spectrometer on Chandrayaan-3 Pragyan Rover, Inflight performance and measurements

The objective of the Alpha Particle X-ray Spectrometer (APXS) instrument is to analyse several soil/rock samples along the Chandrayaan-3 Pragyan Rover traverse for the major elements with characteristic X-rays in the 1 to 25 keV range. The working principle of APXS involves measuring the intensity of characteristic X-rays emitted from the sample due to Alpha Particle Induced X-ray Emission (PIXE) and X-ray florescence (XRF) processes using suitable radioactive sources, allowing the determination of elements from Na to Br, spanning the energy range of 0.9 to 16 keV. For this experiment, a ^{244}Cm radioactive source has been chosen, which emits both alpha particles and X-rays. A Silicon Drift Detector (SDD) detects X-ray fluorescence emission and energies are identified by subsequent signal processing with readout electronics. After the successful landing on 23rd August, 2023, APXS instrument operations began on

25^{th} August 2023 after the first rover mobility on the lunar surface. At each location of measurement, APXS is powered on and data is acquired when it is stowed position (Figure 36) for five minutes, which provides a spectrum of the calibration plate for assessing the performance of the instrument. Then, the APXS instrument is deployed using a mechanism where the instrument is facing the lunar surface (Figure 36) to make observations of the lunar soil for the nominal duration of ∼45 minutes. In the end, another five minutes of calibration spectrum is acquired in stowed condition before powering off the instrument.

APXS scientific measurements were carried out 23 times for the whole lunar day and in all instances, the APXS instrument operated normally with the instrument performance and health parameters as per expectations. From these measurements, the abundances of Mg, Al, Si, S, Ca, Ti, Cr, Mn, Fe and Ni have been estimated and the scientific assessment of these datasets is in progress. One sample lunar spectrum observed by APXS is shown in Figure 37, which shows all the identified elements. The instrument provided an energy resolution of ∼145eV at 5.9 keV.

Figure 36: APXS in stowed and deployed position

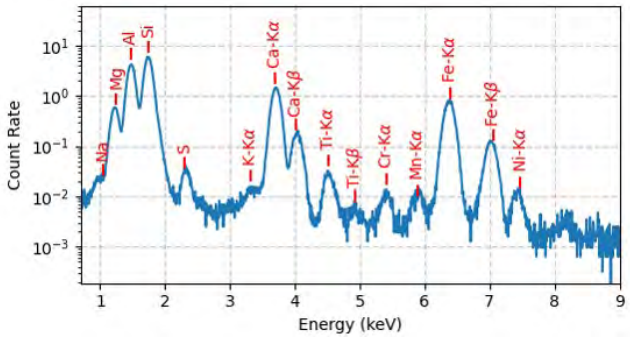

Figure 37: A sample lunar Spectrum observed by APXS.

(M. Shanmugam, S. V. Vadawale, Arpit R. Patel, N. P. S. Mithun, Hitesh Kumar, Tinkal Ladiya, S. K. Goyal, Nishant Singh, Sushil Kumar, Deepak Painkra and Anil Bhardwaj)

Development of Backend Electronics for PRATHIMA payload for LuPEX mission

Permittivity and Thermophysical Investigation for Moons Aquatic Scout (PRATHIMA) is an instrument selected to be flown onboard the ISRO-JAXA LuPEX mission. The main objective of this instrument is the detection and quantification of water-ice within the top half a meter of the lunar soil along the rovers path. We have started development work on Microsemi make ProASIC3PE series of SoCs that have space heritage. We have carried out experiments in ambient conditions with water-ice and mixtures of various ices mixed with lunar analog samples. We have implemented Amplitude and Phase Detection Algorithms (APDA) in MATLAB that utilizes in-built as well as custom-built MATLAB functions to detect the peak amplitude of the received signals and the phase difference between the transmitted and received signals. The algorithm is depicted in Figure 38. This algorithm is being continuously updated and optimized. In the near future, the MATLAB code is planned to be translated into HDL and implemented on the ProASIC3PE FPGA available with us.

As shown in Figure 38, the first requirement in deriving the dielectric constant (ε_r) is finding out A_0 and Φ_0. These are the peak amplitude of the received signal and the phase difference of the received signal with respect to the transmitted signal in vacuum conditions. This set of (A_0, Φ_0) is a constant for all frequencies for a given amplitude of transmitted signal. Once we fix the amplitude of the signal, we get this set of values as a constant for a given probe configuration. The next step involves carrying out measurements in other mediums. For the same probe configuration and the same amplitude of the transmitted frequency, we obtain different A and Φ for different materials. We obtain the relative dielectric permittivity of the material by substituting the four values (A, Φ, A_0, Φ_0) into the following equation:

$$\varepsilon_r = \frac{A_0}{A} \times cos(\Phi - \Phi_0)$$

The phase detector algorithm is in essence, a Zero Crossing Detector (ZCD). The algorithm finds the instances of zero crossing of the amplitude of transmitted as well as received signals and the difference in timing of zero crossing is mapped to phase difference. The steps followed for the peak detection of the received V(t) series is shown in Figure 38.

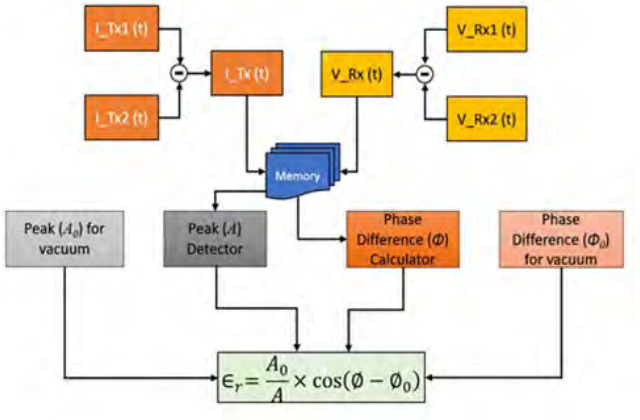

Figure 38: The flow chart of the derivation of relative permittivity (ε_r) using PRATHIMA. The constants A_0 and Φ_0 are obtained by carrying out experiments in vacuum. A and Φ are then obtained for a given medium keeping the probe properties and the excitation schematic.

(Sanjeev K. Mishra, Chandan Kumar, M. Shanmugam and K. Durga Prasad)

Development of Metrology suite and wireless sensor networks project for future missions

We are developing a Miniature Meteorology Sensor Suite (METSuite) with wireless sensor networking capability for future planetary exploration and Earth-based applications. Each device of METSuite weighs ∼100 grams. The target parameters of measurement from the METSuite are, but not limited to, atmospheric pressure, temperature, humidity, wind, solar insolation/radiation (UV-VIS-NIR), and imaging. METSuite is planned to be deployed using a CubeSat and is expected to provide long-term in situ measurements in geographically distinct locations. A laboratory prototype of the instrument has been developed and evaluated (Figure 39). Engineering model design is underway. New electronics scheme was designed and tested to develop the METSuite for future missions. The METSuite electronics contains a low-power ATMEGA 128 microcontroller with a suite of sensors interfaced using onboard (a pressure sensor, temperature sensor, ambient light sensor, humidity sensor and a camera) UART, SPI and I2C protocols. The complete sensor and acquisition electronics without a DC-DC converter will draw 0.1 W power and weigh ∼100 grams. A new Python-based GUI was developed for data analysis and control applications.

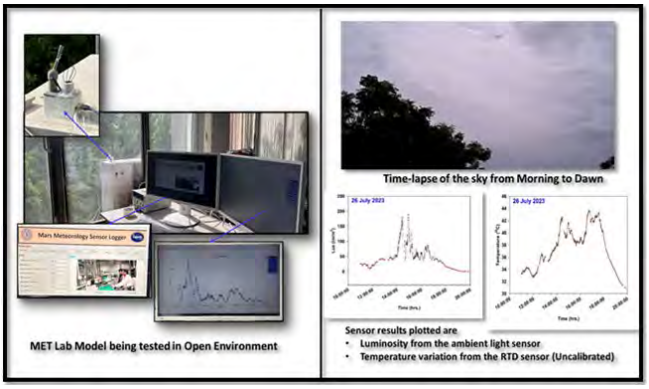

Figure 39: Laboratory evaluation of METsuite through field deployment. Imaging observation and ambient illumination variation throughout the day as observed by the deployed METSuite is also shown in the figure.

(Chandan Kumar and K. Durga Prasad)

Geosciences

Pb-Pb age of the Gotan Limestone, Marwar Supergroup: Implications for Ediacaran-Cambrian transition events in Peninsular India

The rocks of the Marwar Supergroup of western India are known to contain important clues for the evolution of complex multicellular life, changes in the chemistry of ocean water, and changes in global climate during the Proterozoic-Cambrian transition. However, the timings of these event markers remain tentative due to insufficient radiometric ages. Here, we present dating results of the only limestone formation of the supergroup, the Gotan Limestone of the Bilara Group, by Pb-Pb method and use the existing chemo/chrono stratigraphic information to provide constraints on the age of deposition of the supergroup. The $^{207}Pb/^{204}Pb$-$^{206}Pb/^{204}Pb$ isochron yielded an age of 537 ± 19 (2σ) Ma, which agrees with the age estimate suggested by $^{87}Sr/^{86}Sr$ stratigraphy. Therefore, the negative excursions observed in the $\delta^{13}C$ record of the Bilara Group should now be assigned terminal Ediacaran and early Cambrian ages, respectively. This new Pb-Pb age, considered together with $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ stratigraphic records, suggests that the Ediacaran-Cambrian transition in the Marwar Supergroup is likely contained within the Bilara Group, and it is the first such report from the peninsular India.

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(Bivin G. George, Milan K. Mahala & J.S. Ray)

^{10}Be Exposure Age Dating of Moraine Boulders and Glacially Polished Bedrock Surfaces in Karakoram and Ladakh Ranges, NW Himalaya: Implications in Quaternary Glaciation Studies

Quaternary glacial advances and retreats in the northwestern (NW) Himalayas respond to a complex interaction between climatic parameters, that is, temperature and moisture essentially derived from the two contrasting weather systems viz., the Indian Summer Monsoon (ISM) and the Mid-latitude Westerlies (MLW). In this study, we employed terrestrial cosmogenic nuclide (^{10}Be) dating of stratigraphically constrained moraine boulders and striated bedrock surfaces to understand the dynamics of late Quaternary glaciation in the Karakoram and Ladakh ranges. The exposure ages obtained from glacially eroded surfaces (GES) show a narrow cluster around the Marine Isotopic Stage-2 (MIS-2), a period when the northern hemispheric insolation was low, resulting in a temperature decline. The glacial advance during MIS-2 is attributed to the combined effect of temperature reduction and enhanced westerly precipitation. However, relict non-glacial surfaces and moraine boulders with minimal ice flow modifications yield wide age distributions, most likely suggesting denudational events (interglacials) and/or contribution from tributary valley flanks.

doi : https://doi.org/10.1029/2023JF007216

(Ravi Bhushan, Partha Sarathi Jena, Shubhra Sharma, Ankur J. Dabhi, Shivam Ajay, Harsh Raj & Navin Juyal)

Applicability of meteoric ^{10}Be in dating marine sediment cores

Quaternary paleoclimatic and paleomagnetic reconstructions using marine sediment cores require appropriate dating techniques in order to build the chronology. Due to the widespread use of the radiocarbon dating method, the majority of studies focusing on paleo reconstructions are restricted to the last 50 ka. There are very few methods that can be used to obtain chronology beyond the radiocarbon dating limit.

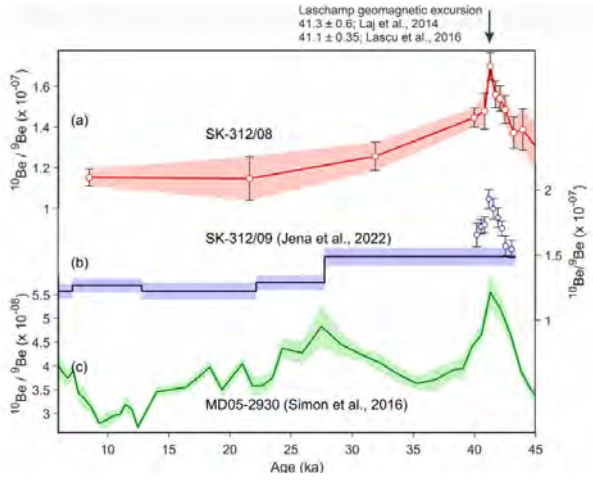

Figure 1: Variation of $^{10}Be/^{9}Be$ ratio in the last 45 ka in the sediment core SK-312/08 compared with $^{10}Be/^{9}Be$ record from sediment core SK/312-09, MD05-2930.

Marine sediment cores as old as 10-12 Ma can be dated using ^{10}Be because of its comparatively long half-life of 1.39 Ma. However, various intricacies restrict this method to date young marine sediment cores (< 1 Ma). In this study, we provide the findings of measurements obtained for beryllium isotopes (^{10}Be and ^{9}Be) in a sediment core from the central Indian Ocean. The changes associated with the decay of 10Be were observed to be much smaller than the Be isotopic fluctuations related to variations in geomagnetic field intensity. Based on the decay of ^{10}Be, the sediment core was dated to be $\sim$350 ka (at 570 cm depth) with an average sedimentation rate of 1.6 cm/ka. Radiocarbon dating in conjunction with beryllium isotope data was employed to decipher the past ^{10}Be production changes due to variations in geomagnetic field intensity over the last 45 ka. A drastic increase in the $^{10}Be/^{9}Be$ ratio at 41.4 ka was attributed

to the Laschamp geomagnetic excursion event (a short-lived Earth's magnetic field reversal from 42,200 to 41,500 years ago). Another anomalous increase in the $^{10}Be/^{9}$ratio was observed at ∼300 cm depth, possibly representing the Iceland Basin event. This study highlights the importance of ^{10}Be as a chronological tool and the limitations associated with various anomalous excursions associated with ^{10}Be production and/or environmental modulations.

doi : https://doi.org/10.1016/j.marchem.2023.104275

(Partha Sarathi, Jena, Ravi Bhushan, Shivam Ajay, Ankur J. Dabhi, Mahesh Gaddam & A.K. Sudheer)

Multi-decadal summer monsoon rainfall trend reversals in South Peninsular India

A long-term (1901-2020) gridded summer monsoon rainfall dataset for the South Indian Peninsula was examined to identify prominent rainfall trend reversals during the last 120 years. The current understanding of long-term rainfall variability in India is largely based on the linear monotonic trend analysis over a large geographical area in which multi-decadal signatures and their geographical variations are missed out. Therefore, multi-decadal rainfall trend variations are not clearly recognized. To overcome this limitation, an innovative, multipronged, and robust methodology based on mathematical and statistical tools was developed involving 31- years moving average of percentage departure of summer monsoon rainfall for 120 years at the district level; 15- year sliding trend analysis to identify the year of inflection point based on a change in direction of the trend; K-Means cluster analysis; Z-score based normality test of clusters; and determination of prominent timeframe of reversal of multi-decadal rainfall trend. Long-term summer monsoon rainfall data (1901-2020) at a district level in South Peninsular India were analyzed using the above methodology. Three major timeframes of rainfall trend reversals during the last 120 years have been identified. These are: (1) from decreasing to increasing rainfall trend around 1934, affecting 67% of the area; (ii) from increasing to decreasing rainfall trend around 1969, affecting 45% of the area; and (iii) from decreasing to increasing rainfall trend around 1986, affecting 45% of the area. The significance of this study is that it identifies systematic reversals in rainfall trends in the long-term rainfall data of India. The study highlights the need to identify the corresponding meteorological, climatic, or anthropogenic causal factors behind the observed rainfall trend reversals.

doi : https://doi.org/10.1016/j.jhydrol.2023.129975

(Swagatika Chakra, Akash Ganguly, Harsh Oza, Virendra Padhya, Amit Pandey & R.D. Deshpande)

Seasonality in groundwater recharge in Coastal Southwestern India and its hydrological implications based on stable isotopes (δ^{18}O, δD)

The spatio-temporal variation in the oxygen and hydrogen isotopic composition (δ^{18}O, δD) of shallow groundwater collected from 225 locations for pre-monsoon and post-monsoon seasons in the southwestern coastal India (Kerala). These samples were examined and interpreted in terms of seasonally varying rainfall, physiography, and hydrogeological settings of this region. In this study, we have identified effective groundwater recharge sources and their relative contributions and provided first-order estimates of submarine groundwater discharge by interpreting the isotopic composition of groundwater in conjunction with that of rainfall. The seasonal changes in the δ^{18}O and d-excess, with other hydrogeological data, revealed that (1) Around 4.9 Billion Cubic Meter (BCM) of fresh water from rainfall during May to October mixes with about 5.9 BCM of residual pre-monsoon groundwater across Kerala. (2) About 11% of the areal extent of Kerala gets additional recharge by the NE monsoon rainfall. (3) The annual groundwater recharge varies from ∼2.2 BCM in the lowland to ∼1.5 BCM in the midland and ∼1.2 BCM in highland regions. (4) On an annual basis, 41% of replenishable groundwater is drained as SGD (submarine groundwater discharge) into the Arabian Sea.

doi : https://doi.org/10.1016/j.pce.2023.103396

(Amit Pandey, Virendra Padhya, Swagatika Chakra & R. D. Deshpande)

Transport pathways of black carbon to a high mountain Himalayan lake during the late Holocene

Historically, forest fires have played a significant role in black carbon (BC) production and distribution, including its deposition in water bodies. BC can reach water bodies through two main pathways: (i) wet and dry atmospheric deposition and (ii) transportation of soil BC via surface runoff. Identifying the transport pathways of BC after the fire has proven to be challenging. PRL conducted a study to decipher the pathway of BC transportation to a lake (Wular Lake, Kashmir Valley, India) by utilizing the nitrogen isotopic composition of BC ($\delta^{15}N_{BC}$) from a sediment core spanning 3744 years. The $\delta^{15}N_{BC}$ record demonstrates that terrestrial N dynamics in the Kashmir Valley were predominantly influenced by shifts in climate conditions during the late Holocene. The observed variations indicated lower $\delta^{15}N_{BC}$, indicative of the dominance of atmospheric transportation of BC to the lake during relatively drier periods with higher forest fire activity. In contrast, higher $\delta^{15}N_{BC}$, suggesting a dominance of soil BC transportation via runoff, aligned with relatively wetter periods of low forest fire activity.

doi : https://doi.org/10.1016/j.palaeo.2023.111865

(A. Rahman, R. A. Shah, A. Rathi, M. G. Yadava & S. Kumar)

Soil organic carbon stock and isotopic signature in tropical island mangrove forests of India

A study was conducted to estimate the soil organic carbon (SOC) stocks across South Andaman Island, Andaman and Nicobar Islands, India. The study also explored the factors responsible for variation between the sites and across estuarine vis--vis marine settings. The

results showed similar mean SOC stock in estuarine and marine mangroves. However, SOC stocks increased from the seaward fringe to the interior and decreased towards the landward fringe and landward mudflats. Further, the soil characteristics, such as bulk density and SOC content, varied significantly across the sites and between the estuarine and marine hydrogeomorphic settings. The mean carbon isotopic composition (δ^{13}C) of mangrove soils of South Andaman Island was about 2‰higher than that of the mangrove leaves, which indicated that the mangrove soils predominantly contained a mixture of detritus from mangrove litters and terrestrial C3 plants. Further, the δ^{13}C values differed significantly across sites and mesoscale hydrogeomorphic settings. Comparing the present results with earlier reports of similar environmental settings (estuarine and marine), it was evident that local factors played a key role in controlling the OC distribution in the mangrove soils of South Andaman Island. Therefore, it is emphasized that the knowledge of variability in SOC stock of mangroves of different environmental settings is imperative for the precise estimation of their carbon storage and climate change mitigation potential.

doi : https://doi.org/10.1007/s10113-023-02130-2

(P. Ragavan, A. Rahman, S. Sarkar, S. Verma & S. Kumar)

Mid-Late Holocene palaeoclimate of Kashmir Valley

Continuous multi-proxy data were generated to understand the mid-late Holocene palaeoenvironmental history of the Kashmir Valley and the lake biogeochemistry of Wular Lake, India. For this purpose, geochemical and stable isotopic analyses were carried out on sediment samples retrieved from a 160 cm long trench excavated on the eastern bank of the Wular Lake located in the Union Territory of Jammu and Kashmir, India. The chronology of the sediment strata developed using ^{14}C dating by AMS method covered the last $\sim$ 5600 yr BP (BP - before present, which is defined as before 1950). Results indicated the occurrence of an extended dry climate phase from 4600 - 3800 yr BP, which coincided with the widely recognized Meghalayan Stage when major civilizations like the Harappa and the Akkadian were known to collapse. The lake biogeochemistry revealed the dominance of the emergent macrophytes during this stage. Another dry phase was observed between 3100 - 2200 yr BP. This dry phase peaked at around 2900 yr BP, coinciding with the Bond event 2. The Wular Lake faced nutrient limitations due to low runoff around 2500 yr BP caused by the persistent dry and cold climate. Geochemical signatures revealed that anthropogenic effects during the last two millennia might have significantly influenced erosion in the catchment area.

doi : https://doi.org/10.1002/jqs.3565

(R.A. Shah, A. Rahman, M. G. Yadava & S. Kumar)

Nitrogen uptake rates in the eutrophic Cochin estuary and adjacent coastal Arabian Sea

This study assessed the Cochin estuary and adjacent coastal Arabian Sea for their seasonal variation in nitrate (NO_3^-) and ammonium (NH_4^+) uptake rates by total and nano+pico plankton using the ^{15}N tracer technique. The results suggested that the $NO_3^-$and NH_4^+ uptake rates in the Cochin estuary are higher than those in the adjacent coastal Arabian Sea. NO_3^- and NH_4^+ uptake rates in the nearshore stations off Cochin were high, indicating the influence of the eutrophic estuary. NO_3^- and NH_4^+ uptake rates off the Mangalore transect were significantly lower than those off Cochin as it does not have an exchange with eutrophic systems. The nano + pico plankton's contribution to the total DIN (dissolved inorganic nitrogen) uptake rates in the Cochin estuary was 77-98%, indicating the relevance of nano+pico phytoplankton in the N cycling of the region.

doi : https://doi.org/10.1016/j.marpolbul.2023.115310

(P.S. Bhavya & S. Kumar)

Sources, supply, and seasonality of total suspended and organic matter in large Asian rivers

Asian rivers, covering $\sim$29 % of the global river surface area, account for $\sim$ 35% of the global freshwater discharge and transport a disproportionately large flux ($\sim$70%) of total suspended matter to the oceans. With recent anthropogenic and climate-induced changes in the flow regimes, it is challenging to constrain the fluxes and elemental signatures of the suspended organic matter in rivers. A study conducted by PRL aimed to understand seasonal changes in the characteristics of total suspended matter (TSM) associated with organic carbon (C) and total nitrogen (N) during high and low flow periods in three large Asian rivers (Ganges, Mekong, and Yellow). By measuring organic C and total N contents and their isotopic compositions at multiple locations along the studied rivers, distinct seasonality in the sources of organic matter was observed. Allochthonous sources dominated the organic matter pool during the high flow condition, whereas autochthonous organic matter derived from enhanced phytoplankton production appeared to have dominated during low flow. C/N ratio showed a positive correlation with altitude during the wet period, which reversed during the dry, supporting the transition of a sediment-dominated high-flow riverine system into a relatively clear and productive low-flow system. Generally, organic matter content in TSM was higher during the low flow with signatures of potential N_2 fixation. Temporal analysis based on present and earlier estimates of fluxes and yields of TSM indicated a manifold decrease in TSM load and associated C and N fluxes over decades in the three river systems, which could be largely attributed to the reduction in river discharge.

doi : https://doi.org/10.3389/feart.2023.1067744

(S. Sarkar, S. Verma & S. Kumar)

Carbon and nitrogen biogeochemistry of a sub-tropical hypersaline lake

Saline lakes across the globe have experienced a severe reduction in their surface area as a result of climate change and human-induced perturbations like water diversion and extraction. The changing

lake volume is predicted to have large-scale implications on the in-lake biogeochemistry. A study conducted by PRL explores the carbon (C) and nitrogen (N) cycling in a desiccating hypersaline lake (Sambhar Lake, India) along with adjacently located brine reservoirs and salt pans by measuring concentrations and stable isotopic ratios of different C and N pools during winter and monsoon. Incubation experiments were also performed to estimate the net nitrification and mineralization rates in lake sediments. The Lake witnessed a large decrease in surface area and showed a clear signature of desiccation on lake biogeochemistry. Both particulate and dissolved fractions of C and N in the lake increased as the lake desiccated from monsoon to winter. Low N isotopic composition (δ^{15}N) of particulate organic matter during winter suggested the presence of N2 fixers in this nutrient-rich saline environment. Taken together, significant differences in C and N concentrations and isotopic compositions were observed across the lake, brine reservoir, and salt pans, suggesting considerable modulation of in-lake processes due to human interventions.

doi : https://doi.org/10.1007/s10750-023-05193-8

(S. Sarkar, A. Khan, N. Sharma, A. Rahman, A. K. Sudheer, R. Bhushan & S. Kumar)

Oxidative Potential of Atmospheric Aerosols over Different Regions of India and Surrounding Oceans

One of the major societal concerns is degrading air quality, which also affects human health and the economy. Aerosol mass concentrations are often considered as the sole measure of their toxicity, and mitigation strategies are largely focused on curbing them. Researchers are trying to establish a link between aerosols and human health through cohort studies; however, such studies lack understanding of underlying mechanisms.

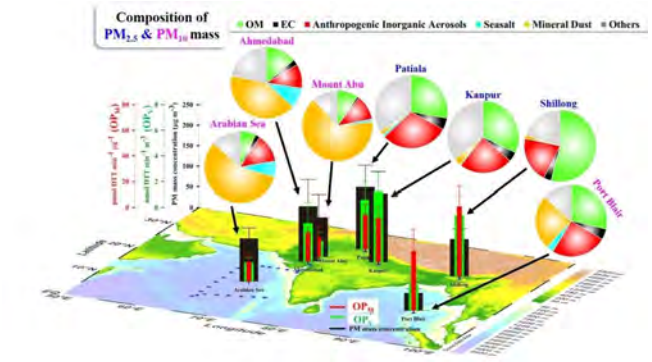

Figure 2: The oxidative potential of atmospheric aerosols (OPV as green bar and OPM as red bar) has been shown with the mass concentration (black bar) and the chemical composition of PM mass (pie charts) over different locations

Aerosol-induced oxidative stress in humans is the widely accepted mechanism explaining how higher aerosol oxidative potential (OP) affects human health. The OP is defined as the capacity of aerosols to generate reactive oxygen species or deplete antioxidants in the human body. In a measurement conducted by PRL over urban, mountain, and marine regions of India, it was found that (1) The OP of combustion-derived aerosols is more than that of non-combustion-derived aerosols, (2) Among the combustion-derived aerosols, biomass burning (BB) derived aerosols have higher OP compared to fossil fuel burning (FFB) derived aerosols, (3) Aerosol OP increases by their atmospheric aging, and (4) Aerosol OP is governed by chemical composition rather than total mass concentration. We suggest that mitigation strategies for reducing aerosol concentrations alone may not be sufficient, and linking aerosol OP with health effects would be a better way to identify and regulate specific sources of toxic aerosol species. Otherwise, even if we reduce overall aerosol mass concentrations substantially, their health benefits may not be in the same proportion.

doi : https://doi.org/10.1021/acsearthspacechem.3c00250

(A. Patel & N. Rastogi)

Wintertime oxidative potential of PM2.5 over a big urban city in the central Indo-Gangetic Plain

Indo-Gangetic Plain (IGP) experiences a heavy load of particulate pollution, impacting around 9% of the global population living in this region. The present study examines the dithiothreitol (DTT) assay-based oxidative potential (OP) of PM2.5 and the major sources responsible for the observed OP over the central IGP (Kanpur) during winter. Although the PM2.5 mass was dominated by secondary aerosols (SA, 28%), followed by crustal dust (CD, 24%), resuspended fine dust (RFD, 14%), traffic emissions (TE, 8%), industrial emissions (IE, 17%), and trash burning (TB, 9%), their proportionate contribution to OP (except SA) was different likely due to differences in redox properties of chemical species coming from these sources. The SA showed the highest contribution (23%) to observed OP, followed by RFD (19%), IE (8%), TE and TB (5%), CD (4%), and others (36%). Our results highlight the significance of determining the chemical composition of particulates along with their mass concentrations for a better understanding of the relationship between PM and health impacts. Such studies are still lacking in the literature, and these results have direct implications for making better mitigation strategies for healthier air quality.

doi : https://doi.org/10.1016/j.scitotenv.2023.167155

(A. Singh, A. Patel, R. Satish, S.N. Tripathi & N. Rastogi)

Summertime oxidative potential of atmospheric PM2.5 over New Delhi: Effect of aerosol aging

Exposure to elevated particulate matter (PM) concentrations in ambient air has become a major health concern in urban areas worldwide. Reactive oxygen species (ROS) generation due to ambient PM (termed as their oxidative potential, OP) is shown to play a major role in PM-induced health effects. In the present study, the OP of the ambient PM2.5 samples collected from New Delhi during the summer of 2019 were measured using the dithiothreitol (DTT) assay.

Average volume-normalized OP (OPV) was 2.9 $\pm$ 1.1 nmol DTT min^{-1} m^{-3}, and mass-normalized OP (OPm) was 61 $\pm$ 29 pmol DTT min^{-1} μg^{-1}. The regression statistics of OPv vs chemical species show the maximum slope of OPV with the elemental carbon (EC, r^2= 0.72) followed by water-soluble organic carbon (WSOC, r^2= 0.72) and organic carbon (OC, r^2= 0.64). A strong positive correlation between OPm and secondary inorganic aerosols (SIA, such as NH_4^+ and NO_3^- mass fractions) was also observed, indicating that the sources emitting NO2 and NH3, precursors of NH_4^+ and NO_3^-, also emit DTT-active species. Interestingly, the slope value of OPv vs OC for aged aerosols (OM/OC $>$ 1.7, f44 $>$ 0.12 and f43 $<$ 0.04) was 1.7 times higher than relatively fresh organic aerosols (OA, OM/OC $<$ 1.7, f44 $<$ 0.12, f43 $>$ 0.04). An increase in OPv and OPoc with f44 indicates the formation of more DTT active species with the aging of OA. A linear increase in OPoc with an increased Nitrogen/Carbon (N/C) ratio suggests that nitrogenous OA has higher OP.

doi : https://doi.org/10.1016/j.scitotenv.2024.170984

(P.K. Verma, M. Devaprasad, J. Dave, R. Meena, H. Bhowmik, S.N. Tripathi & N. Rastogi)

Dual carbon isotope-based brown carbon aerosol characteristics at a high-altitude site in the northeastern Himalayas: Role of biomass burning

PM2.5 samples (n=34) were collected from January to April 2017 over Shillong (25.7N, 91.9E; 1064 m amsl), a high-altitude site situated in the northeastern Himalayas. The main aim was to understand the sources, characteristics, and optical properties of local vs long-range transported carbonaceous aerosols (CA) using chemical species and dual carbon isotopes (^{13}C and ^{14}C).

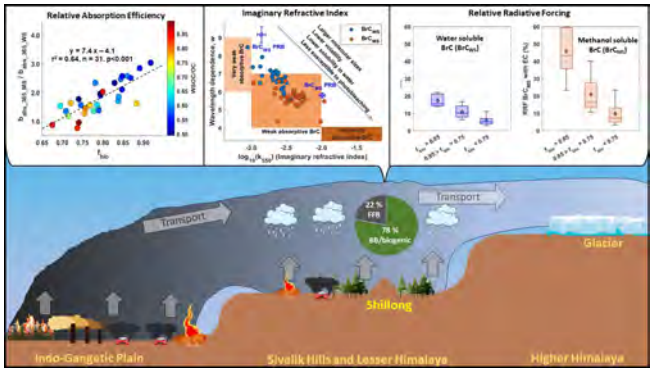

Figure 3: A cartoon representing the long-range transport of aerosols from the Indo-Gangetic Plain to Northeast Himalaya

Percentage biomass burning (BB)/biogenic fraction (f_{bio}, calculated from ^{14}C) varied from 67 to 92% (78$\pm$7) and correlated well with primary BB tracers like f60 (fraction of the signal at m/z 60 to total signals), and K+, suggesting BB as a considerable source. Rain events are shown to reduce the fbio fraction, indicating the majority of BB-derived CA are transported. Further, $\delta^{13}C$ (-26.6$\pm$0.4) variability was very low over Shillong, suggesting its limitations in source apportionment over the study region if used alone. The average ratio of methanol-soluble BrC (BrCMS) absorption coefficient to water-soluble BrC (BrCWS) at 365 nm was 1.8, indicating a significant part of BrC was water-soluble. A good positive correlation between fbio and mass absorption efficiency of BrCWS and BrCMS at 365nm with the higher slope for BrCMS suggests BB-derived water-insoluble BrC was more absorbing. Relative radiative forcing (RRF, 300 to 2500 nm) of BrCWS and BrCMS with respect to EC were 11$\pm$5% and 23$\pm$16%, respectively. Further, the RRF of BrCMS was up to 60%, and that of BrCWS was up to 22% with respect to EC for the samples with fbio $\geq$ 0.85 (i.e., dominated by BB), reflecting the importance of BB in BrC RRF estimation.

doi : https://doi.org/10.1016/j.scitotenv.2023.169451

(M. Devaprasad, N. Rastogi, R. Satish, A. Patel, A. Dabhi, A. Shivam, R. Bhushan & R. Meena)

High Release of Isotopically Depleted CO_2 and CH_4 from the Photo-Degradation of Plastic: A Laboratory Study

This pilot laboratory study reports the direct release of photochemically derived isotopically depleted CO_2 and CH_4 from low-density polyethylene (LDPE) under ambient atmospheric conditions. We investigated the release of CO_2 and CH_4 from two different size fractions of LDPE: coarse (10mm 7mm) and fine (1.5mm 1mm) pieces. Emissions observed at the end of the 45-day incubation experiment were 94 nmol/g CH_4 and 20 μmol/g CO_2 for coarse plastics and 242 nmol/g CH_4 and 42 μmol/g CO_2 for the fine plastics kept in 120 ml vials under the same natural sunlight conditions. Release of CO_2 and CH_4 from the LDPE kept under dark conditions was statistically not distinguishable from blanks (vials without plastics), which attests to the role of photo-degradation in their release. Further, $>$2 times increase in the emissions of CH_4 and CO_2 for fine plastics has important implications as plastic size decreases continuously with their degradation in different environmental compartments. The isotopic composition of carbon ($\delta^{13}C$ of CH_4 (-676 ‰to - 496 ‰) and CO_2 (-132 ‰to -140 ‰) released from the LDPE shows conspicuously depleted signatures, which may have important implications for studies using $\delta^{13}C$ to understand biogeochemical processes in different environmental compartments. The present study necessitates proper accounting of CO_2 and CH_4 release from plastics while studying the biogeochemical cycling of carbon in terrestrial and aquatic environments. More studies with different types and sizes of plastics under different environmental conditions are needed to assess the role of plastics in the CO_2 and CH_4 budgets.

doi : https://doi.org/10.1016/j.pce.2023.103474

(C. Shaw, S. Sarkar, S. Kumar, & N. Rastogi, N.)

The Bay of Bengal: An Enigmatic Diazotrophic Niche

The growth of marine phytoplankton is primarily limited by the reactive forms of nitrogen. Dinitrogen-fixing organisms (termed ”diazotrophs”) supplement this need by providing a natural fertilizerammonium. Our results indicate that N_2 fixation rates were low and supported less than 2% of organic matter formation in the Bay of Bengal during the

spring inter-monsoon. N_2 fixation rates were higher below the oxygen minimum zone than within it. Thus, our study provides additional evidence that N_2 fixation is feasible (low but persistent) in dark marine places with abundant oxygen in conjunction with the surface ocean.

doi : https://doi.org/10.1029/2023JG007687

(H. Saxena, D. Sahoo, S. Nazirahmed, S. Kumar, A.K. Sudheer & A. Singh)

Carbonate clumped isotopes and blocking temperatures of marbles from the Backbone Range, Taiwan

Clumped isotopic compositions (abundance of $^{13}C^{16}O^{18}O$ in CO_2 expressed by Δ_{47}) in massive calcite marble and dolomite marble were measured to estimate the blocking temperatures of marbles and refine our understanding of greenschist-facies metamorphism during the still on-going arc-continent collision from the northern, central, and southern localities along the northern-central Tailuko belt of the Backbone Range of Taiwan. We observed that the carbonate clumped isotope reordering is independent of the grain size of minerals and is less likely affected by lattice defects and active stress. The estimated blocking temperatures for calcites and dolomites are 211 $\pm$ 6 $^\circ$ C and 332 $\pm$8 $^\circ$C respectively, giving respective cooling rates of 614 $^\circ$ C/m.y. and 8.8 10^4 $^\circ$C/m.y. for calcites and dolomites, respectively. We showed that refinements on Δ_{47} - temperature calibration, reordering mechanism, and estimation of thermodynamic constants, in addition to improvement in analytical precision, are needed for the effective use of carbonate clumped thermometry as a tectonic speedometer for metamorphic terranes.

doi : https://doi.org/10.1016/j.jseaes.2023.105975

(Amzad Hussain Laskar)

Mid-Holocene climate-glacier relationship inferred from landforms and relict lake sequence, Southern Zanskar ranges, NW Himalaya.

The para/peri glacial landform assemblages in the Southern Zanskar ranges, NW Himalaya, were investigated using geomorphological mapping, elemental geochemistry, and optical chronology to understand the relationship between glacial dynamics and the lake sedimentation during the mid-Holocene climate variability. The minor cirque glacier advances inferred from three generations of moraines were dated using optical chronology to 11.4$\pm$0.9, 5.3$\pm$0.6, and 4.8$\pm$0.8 ka. The major and trace element geochemistry of the relict lake sediments indicates six centennial to millennial-scale climatic phases. The prominent warmer phases (5.9-5.5; 3.8-3.4; 2.8-2.5 ka) are represented by decreased mineralogical fine grain flux (low K/Ti, Fe/Si, and Al/Si) with a corresponding increased coarse grain flux (higher Ti/Al and Sr/Al ratios). The increased mineralogical finer fraction (higher K/Ti, Fe/Si, and Al/Si) indicates reduced meltwater flux during cooler phases (5.5-5.1; 3.4-2.8 ka). The advances correspond to major cooling reflected in the geochemical data, and cirque glaciers receded, most likely due to increasing dryness and fluctuating climate. After $\sim$2.6 ka, the development of ice-wedge pseudomorphs indicates the onset of permafrost conditions that degraded after $\sim$2.5 ka, implying an increase in air temperature. The regional climate records suggest that marginal glacier advancements were triggered by enhanced moisture via atmospheric rivers and cooler winter temperatures.

doi : https://doi.org/10.1016/j.geomorph.2023.108953

(S. Sharma & A. Shukla)

Atomic, Molecular and Optical Physics

Mitigating the Source-side Channel Vulnerability by Characterization of Photon Statistics

Quantum key distribution (QKD) theoretically offers unconditional security. Unfortunately, the gap between theory and practice threatens side-channel attacks on practical QKD systems. Many well-known QKD protocols use weak coherent laser pulses to encode the quantum information. These sources differ from ideal single photon sources and follow Poisson statistics. The prepare and measure protocols, such as decoy state and coincidence detection protocols, rely on monitoring the photon statistics to detect any information leakage. The accurate measurement and characterization of photon statistics enable the detection of adversarial attacks and the estimation of secure key rates, strengthening the overall security of the QKD system. We have rigorously characterized our source to estimate the mean photon number employing multiple detectors for comparison against measurements made with a single detector. Furthermore, we have also studied intensity fluctuations to help identify and mitigate any potential information leakage due to state preparation flaws. We aim to bridge the gap between theory and practice to achieve information-theoretic security.

doi : https://doi.org/10.1109/JLT.2024.3361079

(Tanya Sharma, Ayan Biswas, Jayanth Ramakrishnan, Pooja Chandravanshi, R. P. Singh)

Experimental Shot Noise Measurement Using the Imperfect DetectionA Special Case for Pulsed Laser

Measuring the quantum fluctuations of a laser source is the first task in performing continuous-variable quantum key distribution protocols. The quantum fluctuations of the source are measured using balanced homodyne detection. However, achieving ideal conditions for shot noise measurement is challenging due to various detection imperfections. In this work, we have measured the shot noise of a pulsed laser using imperfect homodyne detection. The imperfections accounted for in the detection process are a delay between the homodyne output arms and also due to the selection of the pulse integration window larger as well as smaller than the photo-current pulse width during the analysis. We have analyzed the imperfect detection results for two different experimental layouts, and a comparative study has been performed. From our analysis, it is evident that these imperfections play a significant role in balanced homodyne detection and must be optimized properly. Both experimental and theoretical analyses are performed to study the parameters' effect. The results are significant since, to date, hardly a few parameters have been explored for time-domain pulsed homodyne detection. The study is essential for the initial characterization of the setup in continuous-variable quantum key distribution (CVQKD) protocols and in optical homodyne tomography (OHT). Our results indicate that balanced homodyne detection can be performed using limited resources, which paves the way for resource-efficient realization of optical homodyne tomography and continuous-variable quantum key distribution.

doi : https://doi.org/10.1109/JQE.2023.3308263

(Anju Rani, Jayanth Ramakrishnan, Tanya Sharma, Pooja Chandravanshi, Ayan Biswas, R. P. Singh)

Free space continuous variable Quantum Key Distribution with discrete phases

Quantum Key Distribution (QKD) offers unconditional security in principle. Many QKD protocols have been proposed and demonstrated to ensure secure communication between two authenticated users. Continuous variable (CV) QKD offers many advantages over discrete variable (DV) QKD since it is cost-effective, compatible with current classical communication technologies, efficient even in daylight, and gives a higher secure key rate. Keeping this in view, we demonstrate a discrete modulated CVQKD protocol in the free space which is robust against polarization drift. We also present the simulation results with a noise model to account for the channel noise and the effects of various parameter changes on the secure key rate. These simulation results help us to verify the experimental results obtained for the implemented CVQKD.

doi : https://doi.org/10.1016/j.physo.2023.100162

(Anju Rani, Pooja Chandravanshi, Jayanth Ramakrishnan, Pravin Vaity, P. Madhusudhan, Tanya Sharma, Pranav Bhardwaj, Ayan Biswas, R. P. Singh)

Scalable QKD Postprocessing System With Reconfigurable Hardware Accelerator

We present a speckle-based deep learning approach for orbital angular momentum (OAM) mode classification. In this method, we have simulated the speckle fields of the LaguerreGauss (LG), HermiteGauss (HG), and superposition modes by multiplying these modes with a random phase function and then taking the Fourier transform. The intensity images of these speckle fields are fed to a

convolutional neural network (CNN) for training a classification model that classifies modes with an accuracy >99%. We have trained and tested our method against the influence of atmospheric turbulence by training the models with perturbed LG, HG, and superposition modes and found that models are still able to classify modes with an accuracy >98%. We have also trained and tested our model with experimental speckle images of LG modes generated by three different ground glasses. We have achieved a maximum accuracy of 96% for the most robust case, where the model is trained with all simulated and experimental data. The novelty of the technique is that one can do the mode classification just by using a small portion of the speckle fields because speckle grains contain the information about the original mode, thus eliminating the need for capturing the whole modal field, which is modal-dependent.

doi : https://doi.org/10.1109/TQE.2023.3326093

This work was carried out in collaboration with Natarajan Venkatachalam, Foram P. Shingala, Selvagangai C, Hema Priya S, and Dillibabu S from the Society for Electronic Transactions and Security, Chennai, India

(Pooja Chandravanshi and R. P. Singh)

Forbidden transitions in highly charged ions with $(n=4,5)d^6$ and $(n=4,5)d^8$ configurations for making optical clocks

By examining the energy level-crossings among the fine-structure manifolds of the $(n=45)d^6$ and $(n=45)d^8$ configurations in a number of highly charged ions (HCIs), suitable forbidden transitions for making single ion-based optical clocks were identified. These clock transitions exhibit quality factors ranging between 10^{16} and 10^{18}, which are larger than most of the previously proposed HCI clock candidates. They also show high sensitivity to the temporal variation of the fine-structure constant and violation of the local Lorentz symmetry invariance. Detailed assessments of the Zeeman, Stark, black-body radiation, and electric quadrupole shifts associated with the above-proposed clock transitions had been conducted to establish the typical order of magnitudes of their fractional uncertainties due to the systematic effects, which are found to be at the 10^{19} level.

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This work was carried out in collaboration with Yan-mei Yu of Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China

(B. K. Sahoo)

All-optical differential radii in Zn isotopes

We conducted high-accuracy calculations of isotope shift (IS) factors of the states involving the D1 and D2 lines in Zn II. Together with a global fit to the available optical IS data, we extracted nuclear-model independent, precise differential radii for a long chain of Zn isotopes. These radii were compared with the ones inferred from the muonic x-ray measurements. Some deviations were found, which we ascribed to the deformed nature of Zn nuclei that introduces nuclear-model dependency into radii extractions from muonic atoms. We arrived at the conclusion that, in cases where the many-body atomic calculations of IS factors were well established, optical determinations of differential radii are more reliable than those from the muonic x-ray measurements, opening the door to obtaining more trustworthy nuclear radii across the nuclear chart.

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This work was carried out along with B. Ohayon of The Helen Diller Quantum Center, Department of Physics, Technion-Israel Institute of Technology, Haifa 3200003, Israel.

(B. K. Sahoo)

High-precision electric dipole polarizabilities of the clock states in ^{133}Cs

High-precision values of the static and dynamic electric dipole (E1) polarizabilities (αF) of the hyperfine levels of the clock transition in ^{133}Cs were reported. The scalar, vector, and tensor components of F were estimated by expressing as the sum of valence, core, core-core, core-valence, and valence-core contributions that are arising from the virtual and core intermediate states. The dominant valence contributions are estimated by combining a large number of matrix elements of the E1 and magnetic dipole hyperfine interaction operators from the relativistic coupled-cluster method and measurements. For an insightful understanding of their accurate determination, intermediate contributions in different forms to the above quantities were given. Very good agreement of the static values for the scalar and tensor components with their experimental results suggested that our estimated dynamic F values can be used reliably to estimate the Stark shifts while conducting high-precision measurements at the respective laser frequency using the clock states of ^{133}Cs.

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(A. Chakraborty and B. K. Sahoo)

Revisiting theoretical analysis of electric dipole moment of ^{129}Xe

The linear response approach to the relativistic coupled-cluster (RCC) theory was extended to estimate contributions from the parity and timereversal violating pseudoscalar-scalar (Ps-S) and scalar-pseudoscalar (S-Ps) electron-nucleus interactions along with electric dipole moments (EDMs) of electrons (de) interacting with internal electric and magnetic fields. The random phase approximation (RPA) was also employed to produce results to compare with the earlier reported values and demonstrated the importance of the non-RPA contributions arising through the RCC method. It showed that contributions from the S-Ps interactions and de arising through

the hyperfine-induced effects are very sensitive to the contributions from the high-lying virtual orbitals. Combining atomic results with the nuclear shell-model calculations in ^{129}Xe, we imposed constraints on the pion-nucleon coupling coefficients, and the EDMs of a proton and a neutron. These results were further used to constrain EDMs and chromo-EDMs of the up-and down-quarks by analyzing the particle physics models.

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This work was carried out in collaboration with Nodoka Yamanaka of Kobayashi-Maskawa Institute for the Origin of Particles and the Universe, Nagoya University, Nagoya 464-8602, Japan and Kota Yanase of Nishina Center for Accelerator-Based Science, RIKEN, Wako 351-0198, Japan

(B. K. Sahoo)

Bayesian phase difference estimation algorithm for direct calculation of fine structure splitting: accelerated simulation of relativistic and quantum many-body effects

Despite rapid progress in the development of quantum algorithms in quantum computing as well as numerical simulation methods in classical computing for atomic and molecular applications, no systematic and comprehensive electronic structure study of atomic systems that covers almost all of the elements in the periodic table using a single quantum algorithm has been reported. In our work, we addressed this gap by implementing the recently proposed quantum algorithm, the Bayesian phase difference estimation (BPDE) approach, to determine fine structure splittings of a wide range of boron-like atomic systems. Since accurate estimates of fine structure splittings strongly depend on the relativistic as well as quantum many-body effects, our study can test the potential of the BPDE approach to produce results close to the experimental values. Our numerical simulations revealed that the BPDE algorithm, in the DiracCoulombBreit framework, can predict fine structure splittings of ground states of the considered systems quite precisely. We performed our simulations of relativistic and electron correlation effects on the Graphics Processing Unit by utilizing NVIDIAs cuQuantum and observed a 42.7 times speedup as compared to the Central Processing Unit-only simulations in an 18-qubit active space.

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(B. K. Sahoo)

Investigating properties of heavy and superheavy atomic systems with p^3 configurations

We investigated energies and spectroscopic properties such as lifetimes, Land g_J factors, and hyperfine-structure constants of the neutral atoms P through Mc belonging to group 15, singly ionized atoms S^+ through Lv^+ of group 16, and doubly ionized atoms Cl^{2+} through Ts^{2+} of group 17 of the periodic table. These elements have np^3 configurations with n= 3 7, which are highly open shells and expected to exhibit strong electron-correlation effects. We used the four-component Dirac-Coulomb Hamiltonian along with the Gaunt term and a relativistic effective core potential while employing the relativistic multireference configuration-interaction method to perform the calculations with sufficient accuracy and compared the results with the available literature data. These comparisons suggested that our predicted values, for which experimental data are not available, are reliable enough to be useful for future applications.

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This work was carried out in collaboration with H. X. Liu and Yy Liu of State Key Laboratory of Metastable Materials Science and Technology and Key Laboratory for Microstructural Material Physics of Hebei Province, School of Science, Yanshan University, Qinhuangdao 066004, China, Y. M. Yu of Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China, and B. B. Suo of Institute of Modern Physics, Northwest University, Xian, Shanxi 710069, China.

(B. K. Sahoo)

Deciphering Core, Valence and Double-Core-Polarization Contributions to Parity Violating Amplitudes in ^{133}Cs using Different Methods

This work examined the accuracy of different many-body methods for the calculations of parity-violating electric dipole $(\mathrm{E1_{PV}})$ amplitudes in atomic systems. In the last decade, many different groups claimed to achieve accuracy below 0.5%, for the $6s^2\mathrm{S}_{1/2} \rightarrow 7s^2\mathrm{S}_{1/2}$ transition in the ^{133}Cs atom. One of the major issues in these calculations was the opposite signs among the core correlation contribution from different works. To estimate the $\mathrm{E1_{PV}}$ of the above transition, various groups had used different many-body methods both in the linear response and sum-over-states approaches. By examining how these methods capture various electron correlation effects, we identified the underlying cause of sign discrepancies in the previously reported results. We also demonstrated how the double-core polarization effects and scaled wave functions influence the estimation of the $\mathrm{E1_{PV}}$ amplitudes. The comprehensive discussions provided in this work will not only aid in our understanding on the potentials of the employed many-body methods, but it will also serve as a road map for improving the $\mathrm{E1_{PV}}$ calculation in the atomic systems further.

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(A. Chakraborty and B. K. Sahoo)

Zr^{3+} ion as a prospective THz atomic clock

We demonstrated how the transition between the fine structure splitting of the ground state of triply ionized zirconium (Zr IV) can be suitable for a terahertz (THz) atomic clock. Its transition frequency is about 37.52 THz and is mainly guided by the magnetic dipole (M1) transition and can be accessible by a readily available laser. We suggested to consider stable even isotopes of Zr and $M_J = \pm 1/2$ sublevels ($i.e. |4D_{3/2}, M_J = \pm 1/2i \rightarrow |4D_{5/2}, M_J = \pm 1/2i$ clock transition) for the experimental advantage. By performing necessary calculations, we estimated possible systematics due to blackbody radiation, ac Stark, electric quadrupole and second-order Zeeman shifts along with shifts due to the second-order Doppler effects. The proposed THz atomic clock can be very useful in quantum thermometry and frequency metrology.

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(A. Chakraborty and B. K. Sahoo)

Simultaneous magic trapping conditions for three additional clock transitions in Yb to search for a variation of the fine-structure constant

We demonstrated that the $4f^{14}6s6p(^3P_2)4f^{13}5d6s^2(^3P_2^*)$ transition in neutral ytterbium (Yb) can serve as an additional clock transition with the highest fine-structure constant (e) varying sensitivity coefficient (q = -46165(3000)). We suggested a scheme to attain simultaneous magic trapping conditions for this clock transition with other two proposed clock transitions $4f^{14}6s^2(^1S_0)^3P_2$ and $^1S_0 - ^3P_2^*$, which also possess very large q values. These conditions can be realized by subjecting Yb atoms to a biased magnetic field by tuning the particular polarization angles of the trapping laser. Upon realization, it can serve as the most potential optical lattice clock to probe αe variation.

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This work was carried out in collaboration with Zhi-Ming Tang, Yang Yang and Y. Zou of Shanghai EBIT Laboratory, Key Laboratory of Nuclear Physics and Ion-Beam Application (MOE), Institute of Modern Physics, Fudan University, Shanghai 200433, Chin, Yan-mei Yu of Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China and Chen-Zhong Dong of Key Laboratory of Atomic and Molecular Physics and Functional Materials of Gansu Province, College of Physics and Electronic Engineering, Northwest Normal University, Lanzhou 730070, China.

(B. K. Sahoo)

Simple experimental realization of optical Hilbert Hotel using scalar and vector fractional vortex beams

Historically, infinity was long considered a vague conceptboundless, endless, larger than the largestwithout any quantifiable mathematical foundation. This view changed in the 1800s through the pioneering work of Georg Cantor, who showed that infinite sets follow their own seemingly paradoxical mathematical rules. In 1924, David Hilbert highlighted the strangeness of infinity through a thought experiment now referred to as the Hilbert Hotel paradox, or simply Hilberts Hotel. The paradox describes a fully occupied imaginary hotel having an infinite number of single-occupancy rooms. The manager can always find a room for new guests by simply shifting current guests to the next highest room, leaving the first room vacant. The investigation of wavefield singularities has uncovered the existence of a direct optical analogy to Hilberts thought experiment. Since then, efforts have been made to investigate the properties of Hilberts Hotel by controlling the dynamics of phase singularities in fractional order optical vortex beams. Here, we have taken such proposals to the next level and experimentally demonstrated Hilberts Hotel using both phase and polarization singularities of optical fields. Using a multi-ramped spiral-phase plate and a supercontinuum source, we generated and controlled fractional-order vortex beams for the practical implementation of Hilberts Hotel in scalar and vector vortex beams. Using a multi-ramped spiral-phase plate, we show the possibility of complicated transitions of the generalized Hilberts Hotel. The generic experimental scheme illustrates the usefulness of structured beams in visualizing unusual mathematical concepts and also for fractional vector beams driven by fundamental and applied research.

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This work was done in collaboration with Mr. Arash Shiri, and Prof. Greg Gbur, University of North Carolina Charlotte, USA.

(Subith Kumar, Anirban Ghosh, Chahat Kaushik, and G. K. Samanta)

Near-video frame rate quantum sensing using Hong-Ou-Mandel interferometry

HongOuMandel (HOM) interference, the bunching of two indistinguishable photons on a balanced beam-splitter, has emerged as a promising tool for quantum sensing. There is a need for wide spectral-bandwidth photon pairs (for high-resolution sensing) with high brightness (for fast sensing). Here, the generation of photon pairs with flexible spectral bandwidth even using single-frequency, continuous-wave diode laser enabling high-precision, real-time sensing is shown. Using 1-mm-long periodically-poled KTP crystal, degenerate, photon-pairs with a spectral bandwidth of 163.42 ± 1.68

nm are produced resulting in a HOM-dip width of 4.01 ± 0.04 m to measure a displacement of 60 nm, and sufficiently high brightness to enable the measurement of vibrations with an amplitude of 205 ± 0.75 nm and frequency of 8 Hz. Fisher-information and maximum likelihood estimation enables optical delay measurements as small as 4.97 nm with precision (CramrRao bound) and accuracy of 0.89 and 0.54 nm, respectively, therefore showing HOM sensing capability for real-time, precision-augmented, in-field quantum sensing applications.

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This work was done in collaboration with Dr. Varun Sharma, currently at Cornel University, USA and Prof. Daniele Faccio, University of Glasgow, UK.

(Sandeep Singh, Vimlesh Kumar, and G. K. Samanta)

Dynamically tunable broadband output coupling of optical oscillators based on non-cyclic geometric phase mirror

We present a uniquely versatile and efficient mirror system capable of real-time fine-tuning in reflection and transmission properties across a broad wavelength range and at a high optical power. Leveraging the principles of the non-cyclic geometric phase (GP) acquired by the clockwise and counterclockwise beams of the Sagnac interferometer satisfying the anti-resonant condition on propagation through the quarter-wave plate, half-wave plate, and quarter-wave plate combination having fast axes oriented at 45 (fixed), θ (variable), and -45 (fixed) with respect to the vertical, respectively, our mirror system offers dynamic transmission control across 0100% without the need for realignment. Notably, the GP-based mirror (GP-mirror) preserves the polarization state of the reflected beam, making it ideal for polarization-sensitive applications. The wavelength insensitivity of the GP enables seamless operation of the mirror across a wide wavelength range. As a proof-of-principle, we use the GP mirror as the output coupler of a continuous-wave, green-pumped, doubly resonant optical parametric oscillator (DRO) based on a 30-mm-long MgO:sPPLT crystal and obtain stable operation at high powers over a wide wavelength tuning range. For a pump power of 5 W, the DRO provides an output power of 2.45 W at an extraction efficiency as high as 49% when operated at optimum output coupling. The DRO shows a maximum pump depletion of 89% and delivers an optimum output power across a tuning range ≥ 90 nm. The demonstrated concept offers a promising approach for advancing the capabilities and control of coherent optical sources tunable across different spectral regions and in all time scales from continuous-wave to ultrafast femtosecond domain.

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This work was done in collaboration with Prof. S. Dutta Gupta, TIFR, Hyderabad, and Prof. Majid Ebrahim-Zadeh, ICFO, Barcelona, Spain.

(Chahat Kaushik, Anirban Ghosh, R. P. Singh, and G. K. Samanta)

Ultraviolet spectrum reveals the presence of ozone on Jupiters moon Callisto

Sulphur dioxide (SO_2) is known to be present on Callisto. In this paper, we studied the chemical evolution of SO_2 astrochemical ice induced by irradiation using 9 eV (137.7 nm) vacuum ultraviolet light produced from the high-flux beamline of the storage ring at the National Synchrotron Radiation Research Centre in Taiwan. Ultraviolet absorption spectra of the irradiated ice recorded in the 240 - 320 nm region reveal a broad absorption band indicating the formation of ozone. By comparing these laboratory spectra with Hubble Space Telescope data of the surface of Callisto in this spectral region, we find compelling evidence to consider the presence of ozone on Callisto. Furthermore, there is an additional band peaking at 309 nm whose assignment is as yet unclear but is quite similar to a band observed on Ganymede, thus leading us to suspect a common molecular source.

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This work is done in collaboration with J I Lo and B M Cheng from Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Taiwan, D V Mifsud from Institute for Nuclear Research (Atomki), Hungary, B N Rajasekhar from RRCAT, Indore, A Das from Institute of Astronomy Space and Earth Science, Kolkata, H Hill from International Space University, France and N J Mason from University of Kent, U.K.

(R Ramachandran, J K Meka, K K Rahul, W Khan, P Janardhan, Anil Bhardwaj, B Sivaraman)

Amorphous 1-propanol interstellar ice beyond its melting point

The recent discovery of 1-propanol $(CH_3CH_2CH_2OH)$ in the interstellar medium (ISM) is of tremendous interest since fatty alcohols have been proposed as constituents of proto-cell membranes. Motivated by this discovery, we present the laboratory mid-infrared (MIR) and vacuum ultraviolet (VUV) absorption spectra of 1-propanol ice under astrochemical conditions, mimicking an icy mantle on cold dust in the ISM. Both MIR and VUV spectra were recorded at ultrahigh vacuum of $\sim 10^{-9}$ mbar and at temperatures ranging from 10 K to sublimation. The morphology of the 1-propanol ice deposited at 10 K was amorphous. By warming the ice to temperatures of 140 K and above, with subsequent recording of IR spectra, we observe complete sublimation of 1-propanol molecules from the substrate around 170 K. No amorphous-to-crystalline phase change was observed upon warming to higher temperatures. Additionally, we observe the IR and VUV signatures of 1-propanol ice on the substrate well beyond its melting point (147 K). To the best of our knowledge, this is the first reported observation of a molecular ice staying well beyond its melting point under such conditions. This result shows that the morphology of icy mantles on ISM cold dust grains is more complex than previously thought. Our atomistic molecular dynamics simulations capture the experimental trends and shed light on the microscopic origin of this unusual phase behaviour of 1-propanol.

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This work is done in collaboration with A Hazarika, S Nag, S Yashonath and Prabal K Maiti from IISc, Bengaluru, Tejender S Thakur from CSIRCentral Research Drug Institute, Lucknow, S L Chou and Y J Wu from National Synchrotron Radiation Research Center, Taiwan, G Vishwakarma from IIT-Madras, B N Rajasekhar from RRCAT, Indore, and N J Mason from University of Kent, U.K.

(R Ramachandran, S Gupta, J K Meka, P Janardhan, B N Rajasekhar, Anil Bhardwaj, B Sivaraman)

Stability and morphology of cyano naphthalene icy mantles on ISM cold dust analogs

The recent identification of the polycyclic aromatic hydrocarbon molecules, 1-cyano naphthalene and 2-cyano naphthalene in the interstellar medium (ISM) requires laboratory support in order to understand the physicochemical nature of these molecules when they are present as icy mantles on cold dust grains. Therefore, we have carried out infrared spectroscopic characterization of these molecules under astrochemical conditions. When deposited at 7 K, the spectra of the cyano naphthalene ices were amorphous in nature. Upon warming to higher temperatures, cyano naphthalene ices appear to remain amorphous until sublimation. Both sublimate at very high temperatures, 250 K - 265 K, suggesting their presence on the ISM dust over a large temperature range such that they may influence the chemical complexity across the ISM.

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(R Ramachandran, K K Rahul, J K Meka, A Roy, P Janardhan, Anil Bhardwaj, B Sivaraman)

Detection of polycyclic aromatic hydrocarbon on a sample of comets

We present here the spectral properties of a selection of comets from the Jupiter family and Oort cloud at ultraviolet (UV) and mid-infrared (IR) wavelength regions. The spectroscopic studies from the public archival data in the near-UV (NUV) and far-UV (FUV) wavelengths from International Ultraviolet Explorer (IUE) and Hubble Space Telescope (HST) observations showed emissions of Polycyclic Aromatic Hydrocarbon molecules like pentacene $(C_{22}H_{14})$ at 190, 280 nm and toluene (C_7H_8) at 268 nm. The UV spectra of the comets also showed emissions due to CS, Fe II, and CO Cameron bands, C I, S I, and O I. The archival mid-IR spectroscopic observations made using an Infrared Spectrograph (IRS) on board the Spitzer Space Telescope on a few comets showed the presence of PAH (Polycyclic Aromatic Hydrocarbons)bands at 6.2, 7.7, 8.6, 11.2 m after subtracting the continuum from the observed spectra. Mid-IR spectra of the comets in our sample also showed the presence of silicate at 9.6 m. The similarity of PAH signatures observed in the proto-planetary disk of young stellar objects, meteorites, interplanetary dust particles, and comets with those observed in the interstellar medium (ISM) suggests a possible scenario for the incorporation of PAH from ISM onto the primordial solar nebula thereby establishing a possible link.

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This work is done in collaboration with V Venkataraman, Space Physics Laboratory, Vikram Sarabhai Space Center, H. M Quitian-Lara and N J Mason from University of Kent, U.K., B N Rajasekhar from RRCAT, Indore and H Hill from International Space University, France.

(Arijit Roy, R Ramachandran, Anil Bhardwaj, B Sivaraman)

Molecular growth of PANH via intermolecular Coulombic decay

In this study, we investigated the molecular growth under UV photoionization. We show that light can efficiently initiate the molecular mass growth of Nitrogen-bearing polycyclic aromatic hydrocarbons (PANHs). The experiment was performed on quinoline molecules, in which intermolecular Coulombic decay between the associating monomers formed the cations of quinoline-dimer. Molecular rearrangements in the dimer cation lead to a dominant formation of cations heavier than quinoline. The enrichment of these heavier cations over all the other cations reveals the efficiency of this route for the mass growth of PANHs in space. This mechanism also leads to a highly reactive unsaturated PANH-ring via CH loss, a hitherto unknown channel in any photon-driven process. The occurrence of this efficient pathway toward complex molecules points to a rich chemistry in dense interstellar clouds.

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This work is done in collaboration with Prof. G Arvind, IIT Madras

(Rajesh K. Kushwaha)

A new post-violet infrared stimulated luminescence (pVIRSL) dating protocol for potassium feldspar

In this work, we developed a new dating protocol for feldspar, which has low fading, better bleachability and dose estimation parameters than existing methods. Devi et al. (2022) suggested that post-violet infrared stimulated luminescence (pVIRSL; IRSL at 100 C after a violet bleach at 50 C) of K-feldspars, generally has a near zero athermal fading rate. This study explores the mechanism and suitability of the pVIRSL signal for dating applications. The results suggest that pVIRSL is a recuperated signal, arising from the eviction of charges in deep traps by violet stimulation followed by their recapture to the IR traps. A post-violet IR single aliquot regenerative dose (pVIR-SAR) protocol worked well for seven K-feldspar samples from varied depositional environments with ages ranging from 6 to 286 ka. The pVIRSL paleo-doses of most samples, accorded with paleodoses computed using the published ages and their environmental dose rates.

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(Monika Devi, Naveen Chauhan, A.K Singhvi)

Luminescence for Sediment Budgeting

Multiple luminescence signals such as optically stimulated luminescence, infrared stimulated luminescence and thermoluminescence

etc. are characteristic of the crystal/material. Recent studies have shown the potential of luminescence signals for sedimentary provenance studies, sediment fingerprinting, and tracking. It is based on the premise that different provenances have different compositions of trace impurities in minerals which are responsible for the luminescence properties of the minerals. However, the use of luminescence for provenance studies is still in its developmental stage and needs validation in modern sediments. The current work utilizes the differences in the luminescence signals from different geological provenances to quantitatively estimate the sediment influx to the mainstream from its tributaries based on a 2-component mixing model. Samples from natural river confluences and control samples prepared by mixing two samples in a known proportion by weight were used to estimate the sediment flux based on the luminescence characteristics. This study successfully demonstrates the use of luminescence parameters for sediment fingerprinting and budgeting using natural and controlled samples.

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This work is done in collaboration with Dr. Linto Alappat from Christ College Kerala

(Kartika Goswami, Santunu Panda, ,Naveen Chauhan)

Tectonic studies along the Himalayan Frontal Thrust and implications for seismic hazard

This work studies the slip rates along the Himalayan Frontal Thrust in Nahan Salient, which is linked to the seismic hazards in the region. Normally protracted interseismic locking of the low-angle dcollement of the Himalayas causes strain accumulation and results in a growing slip deficit with time. Unlocking the frontal splay of the dcollement during high-magnitude earthquakes $(\mathrm{M}w \geq 6.5)$ may cause surface ruptures along the Himalayan Frontal Thrust (HFT). According to Paleoseismic investigations and observations on undeformed fluvial strath surfaces, the HFT in Nahan Salient has not experienced coseismic slip at least for the last six to seven centuries. Our new observations and chronological assessments on folded and faulted fluvial strath surfaces on the hanging wall of the HFT indicate a maximum slip rate of $10.4 \pm 0.8 - 12.2 \pm 0.8 mm/a$ (averaged over the last 78ka). Seismic quiescence of 600700 results in a $\sim 6.2 - 8.5m$ slip deficit on the HFT which could trigger a $\mathrm{M}w \geq 7.7$ earthquake. Our findings underline an enormous seismic risk prevailing in the Nahan area.

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This work is done in collaboration with Shantamoy Guha from the Czech Academy of Sciences; and Saptarshi Dey and Ajit Singh from IIT Gandhinagar

(Rahul Kumar Kaushal and Naveen Chauhan)

Dating the Youngest Toba Tuff deposits in the Gundlakamma River basin and its implication for understanding Human evolution

The eruption of Toba ca. 75 ka was the largest volcanic eruptive event during the Quaternary, and evidence for this eruption is widespread in terrestrial sediment sequences in South Asia as primary and reworked distal ash deposits. Youngest Toba Tuff horizons (YTT) have been widely employed as isochrons to understand and link regional sediment sequences and the evidence for environmental and cultural change in the archaeological records preserved within them. We identify the YTT deposits at Retlapalle, Andhra Pradesh, India, and present the optical ages of the K-feldspar grains recovered from sediments immediately underlying and overlying the tephra horizon. We combine these results with particle size and magnetic susceptibility analyses to establish the depositional conditions of YTT, which indicate that accumulation and reworking ceased by ca. 64 ka. We explore the role of YTT deposits as an isochron for examining the effect of the 75 ka Toba super-eruption, highlighting the need for an independent chronological assessment of YTT before using it as a Late Pleistocene chronological marker in reconstructing South Asian paleo-landscapes and hominin adaptations. Further, our findings support the regional continuity of human occupations within South Asia, spanning the eruption of Toba and the enduring utility of Middle Paleolithic tools.

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This work is done in collaboration with Anil Devara, Prof. P. Ajithprasad and Vrushab Mahesh from MSU, Baroda; Prof. James Blinkhorn from University of London; Victoria Smith from University of Oxford; , Satish Sanghode from Savitribhai Phule University, Pune; and Zakir Khan from Pt. Ravishankar, Shukla University, Raipur

(Monika Devi and Naveen Chauhan)

Dating Palaeolithic tools of MIS 3 Levallois technology from Motravulapadu, Andhra Pradesh, India

This work dates the sediment layers associated with Palaeolithic tools. The chronology and hominin association of the South Asian Middle Palaeolithic have attracted much attention in the last few decades. The emergence of Middle Palaeolithic culture in the region has been debated between the local origins (behavioural change) model based on an early date around 380 ka and the diffusion (biological change) model based on Homo sapiens dispersals from Africa around 12080 ka. The latter has more consensus, whereas the former requires a more robust chronological framework to attribute the emergence of the Middle Palaeolithic to behavioural changes. In the absence of hominin remains, the presence of Middle Palaeolithic technological trajectories are frequently used as behavioural markers of Homo sapiens. Homo sapiens fossil remains from the regions between Africa and South Asia dated to ~ 200 ka presents more convincing support for the latter model. Here we present contextual, chronological and technological analysis of Middle Palaeolithic assemblages dated to 52 ka from Motravulapadu, Andhra Pradesh, India. Morphometrical analysis of the lithic assemblage indicates diverse Levallois core reductions were practised at the site at the onset of MIS 3. Further this evidence highlights the significance of MIS 3 cultural diversity in South Asia, likely related to changing population dynamics, cultural drift, and the highly variable climatic context of MIS 3.

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This work is done in collaboration with Anil Devara, Neha Ati, C. P Mukesh, Akash Pandey, Prof. P. Ajithprasad and Vrushab Mahesh from MSU, Baroda; Gopesh Jha, from Eberhard-Karls-Universitt Tbingen, Tbingen, Germany, and Zakir Khan from Pt. Ravishankar, Shukla University, Raipur

(Monika Devi and Naveen Chauhan)

Thermoluminescence (TL) studies of Eu^{3+} doped Sr_2YVO_6 double perovskite phosphor.

This work studies the Thermoluminescence kinetic parameters of Eu^{3+} doped Sr_2YVO_6 synthesized through traditional high-temperature combustion. A series of luminescent orange-red emitting Sr2YVO6:Eu3+ double perovskite phosphors were prepared, and their luminescence properties were examined. Through X-ray diffraction (XRD) and Rietveld analysis, the monoclinic crystal structure of all prepared $Sr_2YVO_6 : Eu^{3+}$ phosphors were confirmed. Scanning electron microscopy (SEM) was used to analyse the morphology of the phosphor. Under 320 nm excitation, Eu^{3+} doped Sr_2YVO_6 phosphors exhibit very strong red photoluminescence (PL) emission bands at 595 nm, 616 nm and 620 nm as well as distinct red emission bands at 653 nm and 699 nm, which are originated due to the $5D0 - 7FJ(J = 1,2,3,4)$ transition of Eu^{3+}. A series of phosphor also exhibit orange-red emission at 595 nm, 612 nm, 616 nm and 620 nm under the excitation wavelength of 396 nm. High color purity of the phosphors is revealed by calculated color purity and excellent chromaticity coordinates, which also confirms the presence of far-red luminescence emission. After the irradiation of the phosphors at various beta doses via $90Sr/90Y$ beta source, the thermoluminescence (TL) studies of Eu^{3+} activated Sr_2YVO_6 phosphors was conducted. Exposer of beta irradiation revises a prominent TL glow curve at 124 C with a small hump at around 290 C, indicating the development of different trap centres in the phosphor. As the dose of beta radiation increased, a linear dose response was observed in TL intensity. Computerised Glow Curve Deconvolution (CGCD) method and Chen's Peak Shape Method (PSM) were used to determine the activation energies and trapping parameters of TL glow curves. According to CGCD fitting of TL glow curves, it is found that all glow curves consist of five deconvoluted peaks, which follows general order kinetics. Activation energies calculated through different methods were comparable and significant.

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This work is done in collaboration with Naresh Degda, Nimesh Patel, Vishwnath Verma, Dr. M. Srinivas and Prof. K.V.R. Murthy from MSU Baroda

(Malika Singhal and Naveen Chauhan)

Structural and optical properties of $Zn_{2.95}Ga_2 - xSnO_8 : xCr^{3+}$: An excellent X-ray charging-based persistent phosphor

This study investigates the structural and luminescence properties of Cr^{3+} doped $Zn_{2.95}Ga_2SnO_8$ phosphor. XRD analysis determines the phase purity and lattice parameters, while SEM and TEM analysis were utilized to study the particle size and surface morphology of the sample. UVvisible absorption and PL excitation spectra provided information on the excitation bands and the band-gap of both the undoped and Cr^{3+} doped $Zn_{2.95}Ga_2SnO_8$. The optical band-gap of the material decreases upon doping with $Cr3+$ ions. Analysis of the Racah parameter and Tanabe Sugano diagram highlights a robust crystal field within $Cr^{3+} : Zn_{2.95}Ga_2SnO_8$, causing 2Eg level to become the lowest excited state with sharp emission at 699 nm. Concentration quenching at higher Cr^{3+} concentrations $(> 0.6mol\%)$ is primarily attributed to the quadrupole-quadrupole interactions. Two distinct traps with trap depths at 0.51 eV and 0.73 eV were identified by using thermoluminescence measurement. The material gives persistent luminescence with a decay time of more than 30 min when charged with blue light (420 nm) and an excellent decay time of more than 16 h when charged with X-rays. Notably, this is the first report on X-ray charging-based persistent luminescence in $Zn_{2.95}Ga_2SnO_8$. The outstanding persistent luminescence makes this material highly promising for various applications.

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This work is done in collaboration with Shruti Sajwan, Manisha Sharma, Santosh Kachhap and Sunil Kumar Singh, from IITBHU, Varanasi ; Akhilesh Kumar Singh from Banasthali Vidyapith ; Mohit Tyagi and Partha Sarathi Sarkar from BARC Mumbai

(Malika Singhal and Naveen Chauhan)

East Antarctica ice sheet in Schirmacher Oasis, Central Dronning Maud Land, during the past 158 ka

This study dates sediments from East Antarctica ice sheets and studies the climate and glacial extent during the sediment depositions. Varied geomorphic landforms along the coast of eastern Antarctica suggest that the most recent phase of ice retreat was spatially heterogeneous. Ice retreat here comprised; a thinning of the East Antarctic Ice Sheet (EAIS) by up to 500 m and the recession of the ice wall in kilometre. This retreat deposited moraines over the Schirmacher Oasis (SO) in central Dronning Maud Land with minimal reworking. The present study used optical dating of the recessional moraines to determine the timing of their final emplacement. Three phases of moraine deposition, during 158125 ka; 7650 ka and 22 ka to present, were inferred. It is suggested that decreased sea surface temperatures and increased sea ice cover of the surrounding oceans limited the moisture supply and led to the retreat of ice. By~ 35 ka the SO became ice-free and has remained so, ever since. The inference that the ice sheet in this region was moisture limited, implies that in a global warming context, this region may not contribute to an increase in sea-level. Instead, a warming-induced increase in moisture supply may even add to ice cover in the region.

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This work is done in collaboration Sandip Kumar Roy, Prakash Kumar Shrivastava, Rajesh Asthana, , Syed Ali Imam Mujtaba from GSI

(Naveen Chauhan and Ashok Kumar Singhvi)

Influence of pressure and pulse energy on the expansion dynamics of nanoparticle-enhanced laser-produced plasma

This is a novel work first carried out by our group at PRL to study the plume dynamics of the nanoparticle-enhanced laser-produced plasma (NELPP). In this work, we have studied the influence of pressure and pulse energy on the expansion dynamics of NELPP for two different metals, copper and aluminum. Although the spectroscopic investigation of signal enhancement of emission line intensities in the presence of nanoparticles (NPs), and nanoparticle-enhanced LIBS (NELIBS), has been performed extensively, expansion dynamics for NELIBS have not yet studied. We have carried out a detailed investigation of the plume propagation of NELPP for different pulse energies and ambient pressures. The temporal evolution of the distance of propagation of the plume front at different laser fluences and pressures shows a good agreement with the existing theoretical models. The R-t plots obtained for NELPP are governed by the drag model in the atmosphere, the adiabatic expansion model at lower pressure, and the blast wave model in 1 mbar Argon gas, as also seen in the case of LPP. By comparing different plume propagation parameters, such as diameter, aspect ratio, and expansion velocity, we have shown that the NELPP plume shows similar behavior as of LPP and its evolution can be explained with the existing models. Hence NPs, though influence the ablation process, do not alter the overall plume dynamics during the course of plasma evolution as observed for the two metals.

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(Swetapuspa Soumyashree and Prashant Kumar)

Impact of viscosity of liquid on nanoparticles synthesized by laser ablation in liquid

Pulsed laser ablation in liquid (PLAL) has gained popularity over time as an efficient method for the fabrication of nanoparticles (NPs). This method depends on laser-induced dynamics at the solid-liquid interface, which is influenced by the experimental parameters. Hence, it becomes necessary to study the effect of various parameters for efficient synthesis of NPs and better control over their properties. The present study elucidates the role of liquid ambient in determining the properties of NPs. The effect of viscosity on the size of NPs is studied by conducting experiments in three liquids, viz., Distilled water (DW), propylene glycol (PG), and glycerol (GOL). This study uncovers that the size of NPs significantly depends on the viscosity of the liquid. The dynamical processes of PLAL were probed using the optical beam deflection technique with an attempt to connect the NP size distribution to the bubble size in the respective liquid. Laser-produced craters were studied to know their effect on surface morphology. Theoretical calculation of the binding energies of PG and GOL complement the experimental results. The study performed will help to further enhance the control over NPs during PLAL.

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This work is done in collaboration with Kavil Mehta and Prahlad Baruah from PDEU, Gandhinagar, and Jhuma Saha from IIT, Gandhinagar

(Swetapuspa Soumyashree, Prashant Kumar, Rajesh K Kushawaha)

Analysing the Grain size and asymmetry of the particle distribution using auto-correlation technique

Extracting the grain size from the microscopic images is a rigorous task involving much human expertise and manual effort. While calculating the grain size, we will be utilizing a finite number of particles which may lead to an uncertainty in the measurement. To avoid this difficulty, we utilize a simple mathematical tool, the auto-correlation function, to determine the grain size. The random particle distribution and the finite width Gaussian histogram of particle size have motivated us to utilize the auto-correlation function, which has been extensively studied for finding the size of random optical patterns. The finite width of the correlation function provides the grain size, and the difference in correlation length along two mutually independent directions provides information about the asymmetry present in the particle distribution, i.e., the deviation from a spherical shape. The results may find applications in material, pharmaceutical, chemical, and biological studies where extracting the grain size is essential.

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This work is done in collaboration with Vanitha Patnala, Gangi Reddy Salla from SRM University AP, Amaravati, Mangalagiri 522502, Andhra Pradesh, India, and Venkateswarlu Annapureddy from Department of Physics, National Institute of Technology, Tiruchirappalli 620015, Tamil Nadu, India

(Shashi Prabhakar, R. P. Singh)

Vulnerability in Free Space QKD Due to Detection Coupling Mismatch

Practical implementations of QKD protocols involve devices that are not perfect, and an eavesdropper may exploit this to gain information leading to attacks. Here we have considered the effects of coupling mismatch between the detectors. We find possible information leakage to Eve due to a coupling mismatch at the receivers detectors in terms of mutual information between the eavesdropper and receiver. The experiment has been performed for the Gaussian and Laguerre-Gaussian modes of the signal. This aspect becomes essential while implementing free space QKD using a satellite. The results suggest that accounting for the detection of coupling mismatch is crucial to avoid side-channel attacks.

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This work is done in collaboration with Ayan Biswas from the School of Physics, Engineering, and Technology and the York Centre for Quantum Technologies, Institute for Safe Autonomy, the University of York, YO10 5FT York, U.K

(Tanya Sharma, Pooja Chandravanshi, Shashi Prabhakar, and R. P. Singh)

3D incoherent imaging using an ensemble of sparse self-rotating beams

Interferenceless coded aperture correlation holography (I-COACH) is one of the simplest incoherent holography techniques. In I-COACH, the light from an object is modulated by a coded mask, and the resulting intensity distribution is recorded. The 3D image of the object is reconstructed by processing the object intensity distribution with the pre-recorded 3D point spread intensity distributions. The first version of I-COACH was implemented using a scattering phase mask, which makes its implementation challenging in light-sensitive experiments. The I-COACH technique gradually evolved with the advancement in the engineering of coded phase masks that retain randomness but improve the concentration of light in smaller areas in the image sensor. In this direction, I-COACH was demonstrated using weakly scattered intensity patterns, dot patterns, and recently using accelerating Airy patterns, and the case with accelerating Airy patterns exhibited the highest SNR. In this study, we propose and demonstrate I-COACH with an ensemble of self-rotating beams. Unlike accelerating Airy beams, self-rotating beams exhibit a better energy concentration. In the case of self-rotating beams, the uniqueness of the intensity distributions with depth is attributed to the rotation of the intensity pattern as opposed to the shifts of the Airy patterns, making the intensity distribution stable along depths. A significant improvement in SNR was observed in optical experiments.

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(Shashi Prabhakar and R. P. Singh)

Intensity correlations in perturbed optical vortices

We propose and experimentally verify a novel scheme for diagnosing the order of a perturbed optical vortex using its 2D spatial autocorrelation function. The order of a vortex was found to be equal to the number of dark rings or zero points present in the correlation function. We have provided a compact analytical expression for the correlation function in the form of Laguerre polynomials. Further, we have utilized the divergence of the first zero point of Laguerre polynomials upon propagation to obtain information about higher-order vortex beams and compared it with our experimental results. It has been shown that the accuracy of the obtained information can further be enhanced by increasing the collection area of scattered vortex beams. These results find applications in free-space optical and satellite communication as the proposed technique is alignment-free, and information can be obtained even with a small portion of the scattered beam.

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This work is done in collaboration with Vanitha Patnala, M. Bhargavi, Gangi Reddy Salla from SRM University AP, Amaravati, Mangalagiri, India; and Venkateswarlu Annapureddy from Department of Physics, National Institute of Technology, Tiruchirappalli, India

(Shashi Prabhakar, J. Banerji, and R. P. Singh)

Endless fun in high dimensions - A quantum card game

Quantum technologies enable new ways to distribute and process information. The enormous progress over the recent decades has led to an urgent need for new educational programs to train professionals to work in this field. Here, we present a card game that teaches students the building blocks of quantum computing through strategic gameplay. Participants start from the lowest quantum state and play cards that change their state and/or their opponents state, aiming to build an algorithm that achieves the highest possible quantum state. Players can utilize several different strategies that rely on quantum features such as randomness, superposition, interference, and entanglement. Our game expands on the existing Q$|Cards>$ game, originally developed using traditional qubits (with 2-level states), by including an option to play with qutrits (with 3-level states), and by developing cooperative and single-player modes in addition to the existing competitive mode. The presented game contributes to the ongoing efforts on gamifying quantum physics education with a particular focus on the counter-intuitive features that make quantum computing powerful.

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This work is done in collaboration with Lea Kopf, Markus Hiekkamki, and Robert Fickler from Photonics Laboratory, Physics Unit, Tampere University, Tampere FI-33720, Finland

(Shashi Prabhakar)

Multi-User Nonlinear Optical Cryptosystem Based on Polar Decomposition and Fractional Vortex Speckle Patterns

In this paper, we propose a new multiuser nonlinear optical cryptosystem using fractional-order vortex speckle (FOVS) patterns as security keys. In conventional optical cryptosystems, mostly random phase masks are used as the security keys which are prone to various attacks such as brute force attacks. In the current study, the FOVSs are generated optically by the scattering of the fractional-order vortex beam, known for its azimuthal phase and helical wavefronts, through a ground glass diffuser. FOVSs have a remarkable property that makes them almost impossible to replicate. In the input plane, the amplitude image is rst phase encoded and then modulated

with the FOVS phase mask to obtain the complex image. This complex image is further processed to obtain the encrypted image using the proposed method. Two private security keys are obtained through polar decomposition which enables the multi-user capability in the cryptosystem. The robustness of the proposed method is tested against existing attacks such as the contamination attack and known-plaintext attack. Numerical simulations conrm the validity and feasibility of the proposed method.

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This work is done in collaboration with Vinny Cris Mandapati, Harsh Vardhan, Ravi Kumar, Salla Gangi Reddy from Department of Physics, SRM University-AP, Andhra Pradesh 522502, India; Sakshi from Department of Chemical Engineering, Ben-Gurion University of the Negev, P.O. Box 653, Beer Sheva 8410501, Israel; and Kehar Singh from Optics and Photonics Center, Indian Institute of Technology Delhi, New Delhi 110016, India

(Shashi Prabhakar and R. P. Singh)

Discovery of an Extremely Dense and Compact Object Embedded in the Prestellar Core G208.68-19.92-N2

The internal structure of the prestellar core G208.68-19.02-N2 (G208-N2) in the Orion Molecular Cloud 3 (OMC-3) region has been studied with the Atacama Large Millimeter/submillimeter Array. The dust continuum emission revealed a filamentary structure with a length of $\sim 5000au$ and an average H2 volume density of $\sim 6 \times 10^7 cm^{-3}$. At the tip of this filamentary structure, there is a compact object, which we call a nucleus, with a radius of $\sim 150 - 200au$ and a mass of $\sim 0.1\mathrm{M}\odot$. The nucleus has a central density of $\sim 2 \times 109cm^{-3}$ with a radial density profile of r -1.87 ± 0.11. The density scaling of the nucleus is ~ 3.7 times higher than that of the singular isothermal sphere (SIS). This as well as the very low virial parameter of 0.39 suggests that gravity is dominant over the pressure everywhere in the nucleus. However, there is no sign of CO outflow localized to this nucleus. The filamentary structure is traced by the N2D+ 3-2 emission, but not by the $C^{18}O$ 2-1 emission, implying the significant CO depletion due to high density and cold temperature. Toward the nucleus, the N_2D^+ also shows the signature of depletion. This could imply either the depletion of the parent molecule, N_2 or the presence of the embedded very-low luminosity central source that could sublimate the CO in the very small area. The nucleus in G208-N2 is considered to be a prestellar core on the verge of first hydrostatic core (FHSC) formation or a candidate for the FHSC.

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Hirano, N., Liu, S.-Y., Liu, T., Tatematsu, K., Dutta, S., Li, S., Lee, C.-F., Li, P. S., Hsu, S.-Y., Lin, S.-J., Johnstone, D., Bronfman, L., Chen, H.-R. V., Eden, D. J., Kuan, Y.-J., Kwon, W., Lee, C. W., Liu, H.-L., Rawlings, M. G., Ristorcelli, I., & Traficante, A., The Astrophysical Journal,961,123, (2024)

(Dipen Sahu)

Theoretical Physics

Implications of the DLMA Solution of θ_{12} for IceCube Data Using Different Astrophysical Sources

Neutrinos are the second most abundant particles of the Universe. Three types of neutrinos have been observed in terrestrial experiments. These are the electron, muon and tau type neutrinos. One of the remarkable properties of these fundamental particles is that they can change their identity while traveling and one type of neutrino gets converted to another type. This phenomenon, known as neutrino oscillation, requires neutrinos to be massive and the different types of neutrinos to mix with each other. The parameters involved are the two mass squared differences, three mixing angles and one complex phase. Most of these parameters are already well determined by the oscillation experiments. If there are interactions of neutrinos beyond the standard interactions then some new solutions appear for the mixing angles. One such solution is the Dark-Large Mixing Angle (DLMA) solution which is complementary to the standard Large Mixing Angle (LMA) solution. The LMA solution is close to 33 degrees while the DLMA corresponds to (90-33.4) degrees. We explored the possibility of distinguishing between these two solutions using the data of high energy neutrinos as observed by the IceCube Neutrino experiment in the South pole. We considered various astrophysical sources giving different compositions of the three types of neutrinos and investigated which solution gives a better fit to the data. We also study how the determination of the other yet unknown oscillation parameters are affected in presence of this new solution for the solar mixing angle.

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This work was done in collaboration with M. Ghosh from Center of Excellence for Advanced Materials and Sensing Devices, Ruder Bokovi Institute, Zagreb, Croatia and B. Pavlović from University of Zagreb, Croatia.

(Srubabati Goswami, Supriya Pan)

Matter effect in presence of a sterile neutrino and resolution of the octant degeneracy using a liquid argon detector

Results from accelerator based experiments like Liquid Scintillator Neutrino Detector (LSND) and MiniBooster Neutrino Experiment (MiniBooNE) hint towards the possible presence of an extra light sterile neutrino of mass around 1 electron volt in addition to the three already known neutrinos. The addition of such a neutrino can significantly impact the standard three flavour neutrino oscillations and can affect the precision with which these parameters can be determined. One of the poorly known oscillation parameters is the octant of the neutrino mixing angle known as θ_{23}, and we do not know if it is greater than 45 degree or less than 45 degree. It was shown, using accelerator based neutrino beams, that the inclusion of a sterile neutrino can further spoil the octant determination sensitivity. In our work, we show that if one adds atmospheric neutrino data to the accelerator data, then the octant sensitivity is increased. This is because the atmospheric neutrinos pass through larger distances and experience the matter effect while traveling through the Earth, We use a futuristic liquid argon time projection chamber detector and present the combined sensitivity of beam and atmospheric neutrinos by simulating the data.

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(Animesh Chattterjee, Srubabati Goswami, Supriya Pan)

Probing mass orderings in presence of a very light sterile neutrino in a liquid argon detector

Results from accelerator based experiments like LSND and MiniBooNE hint towards the possible presence of an electron volt (eV) mass sterile neutrino apart from the three standard neutrinos. The sterile neutrinos do not take part in ordinary interactions but can mix with the ordinary active neutrinos. Thus the addition of such a neutrino can significantly impact the standard three flavour neutrino oscillations picture. For an eV scale sterile neutrino, constraints coming from cosmology dictate that the sterile state is heavier than the three active states. However, for lower masses of sterile neutrinos, the sterile state can be lighter than one and/or more of the three states. In such cases, the mass ordering of the sterile neutrinos also becomes unknown, along with the mass ordering of the active states. We explored the mass ordering sensitivity in the presence of a sterile neutrino in the context of a liquid Argon based detector using accelerator neutrinos traveling 1300 km from the source and also atmospheric neutrinos which can traverse distances 10 - 10000 km for reaching the detector. The latter allows one to explore the effect of earths matter on the propagation of the neutrinos. Apart from presenting separate results from these sources, we also do a combined study and probe the synergy between these two in giving an enhanced sensitivity.

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(Animesh Chatterjee, Srubabati Goswami, Supriya Pan)

Rho meson contribution to Neutrinoless Double Beta Decay

Neutrinos being electrically neutral can be their own antiparticles i.e. can be Majorana in nature. If so, lepton number violating decays

like the neutrinoless double beta decay would be a smoking gun signature of the Majorana nature, and connect to neutrino mass. The fundamental level description in terms of quarks and leptons then leads to different types of contributions to such a process: direct contributions to final state nuclei and quarks hadronizing into pions and thus contributing via the long distance effects. This is known to be a large effect in several theoretical models. What about the heavier vector cousin of the pseudoscalar pion, the rho meson? It is shown that due to larger mass, rho contribution is effectively a local one and at the amplitude level can have dramatic impact: for some chiralities, it can almost cancel the usual short range direct contribution while for mixed chiralities, the amplitude can be enhanced. Compared to the pion contribution, it can reach a few tens of percent. This effect is an important one to be considered for phenomenological studies, particularly when aiming for precision.

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(Namit Mahajan)

Axion Like Particles and heavy hadron chiral perturbation theory

Axions are one of the popular candidates postulated to address the strong charge-parity (CP) problem and thus are intimately tied to the deeper structure of the strong interactions. Axions or axion like particles (ALPs) are also well motivated dark matter candidates. Therefore couplings of ALPs to various standard model elementary particles are important parameters to be probed via observations. What about coupling of ALPs to composite particles like mesons and baryons? This question can only be addressed systematically in a low energy theory with these composite particles as the right degrees of freedom. Employing the heavy hadron chiral perturbation theory and building on earlier works on light meson chiral perturbation theory, it is shown how to obtain consistent couplings of ALPs with the heavy mesons. This is particularly useful since such a construction allows to probe couplings which can otherwise never be probed. Some suggestions are made for specific decay modes which can help in an efficient probe of these couplings.

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(Namit Mahajan)

Unitarity bound on dark matter in low-temperature reheating scenarios

Dark matter (DM) is a yet unknown mysterious substance thought to make up most of the matter in the Universe, and such evidence is abundant in exploring a variety of length scales of the Universe. Even while it is so rampant and omnipresent, little is known about the nature or properties of such a substance, possibly due to its heaviness or feeble interaction strength or something we don't know yet. So far, different experiments could constrain the mass and couplings at different ranges, yet leaving a broad range unexplored. In this work, we explore the theoretical upper limit on the mass of dark matter for different cosmological evolutions, i.e., the history of the Universe's expansion. Unitarity computation limits how often DM particles can interact. This limit can be further used to calculate the minimum number of DM particles needed to explain the observed amount of DM in the Universe (its relic density).

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This work was done in collaboration with Nicolás Bernal, New York U., Abu Dhabi, United Arab Emirates

(Partha Konar, Sudipta Show)

Next frontier of IRC-safe feature extraction with Graph Neural Network

Predicting different observables at a particle physics experiment like the Large Hadron Collider requires a thorough knowledge of Quantum Chromodynamics (QCD). It describes the strong interaction that holds the quarks within the proton and protons inside the nucleus despite the repulsion of their positive electric charges. Such calculations also predict the nature of collisions at very high energies whose signature remains in the multitude of stable particles observed at the detectors. Any such observable must follow Infra-Red and Collinear (IRC) safety, i.e., any modification on constituents by a collinear splitting or the addition of a soft emission must keep all the observables in the event unchanged. Many such observables are used to differentiate different types of particle decays. Modern deep-learning algorithms provide a powerful mechanism that takes measured properties as input. They typically forgo such an IRC construction to become susceptible to long-distance physics. We devise a graph neural network algorithm that is IRC-safe by design, making the network output less sensitive to low-energy effects. We find such a general but straightforward architecture to perform on par with other algorithms, which are IRC unsafe.

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This work was done in collaboration with Michael Spannowsky, Institute for Particle Physics Phenomenology, Durham University, United Kingdom

(Partha Konar, Vishal S. Ngairangbam)

Exploring a hidden window of dark matter unlocked by non-standard cosmology

A significant part of our Universe is overwhelmed by some enigmatic yet unknown form of matter or so-called dark matter, leaving only a tiny portion whose properties are very well understood in the standard model of particle physics. It is established in different independent celestial experiments unequivocally, resulting in an active field of research in which PRL groups also participate. Several competing theories exist on how these dark matter particles were produced in the

early phase when the Universe was hot and dense. Such production and evolution of dark matter are intricately connected with how the cosmological history of our Universe evolved. This study explores the possibility of deviating from a standard cosmological history and how the non-trivial expansion affects dark matter production in the early Universe and alters the required search strategies for dark matter detection at colliders. In such a scenario, a standard search at the Large Hadron Collider (LHC) looking for the characteristic long-lived particle and displaced vertex might not represent the best option. A new way of looking at the boosted QCD jets provides the best discovery prospect at the high luminosity LHC for extended parameter space now opened up in the dark sector.

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This work was done in collaboration with Prasanta K Das and Saumyen Kundu, Birla Institute of Technology and Science (BITS-Pilani), Goa

(Partha Konar, Sudipta Show)

Minimal spontaneous CP-violating GUT and predictions for leptonic CP phases

A non-supersymmetric renormalizable $\mathrm{SO}(10)$ model, with CP invariant Yukawa sector consisting of Lorentz scalars in 10 and $\overline{126}$ dimensional representations, is proposed. The elemental Yukawa couplings are real due to CP symmetry. The latter is broken in the low energy effective theory through the standard model Higgs which is a complex linear combination of electroweak doublets residing in 10 and $\overline{126}$ scalars. As a result, the mass matrices in the quark and lepton sectors, including those of heavy and light neutrinos, depend only on three phases which in turn determine CP violation in both sectors. The model is comprehensively analysed for its viability and predictions including the possibility to generate baryon asymmetry through thermal leptogenesis. It predicts relatively small values for CP phases in the lepton sector. Successful leptogenesis further restricts the ranges to $-0.4 \leq \sin\delta \leq 0.4$ for the Dirac phase and $-0.3 \leq \sin\eta_1 \leq 0.2$, $-0.5 \leq \sin\eta_2 \leq 0.5$ for the Majorana phases.

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(Ketan M. Patel)

Gauged $\mathrm{SU}(3)_\mathrm{F}$ and loop induced quark and lepton masses

We investigate a local $\mathrm{SU}(3)_\mathrm{F}$ flavour symmetry for its viability in generating the masses for the quarks and charged leptons of the first two families through radiative corrections. Only the third-generation fermions get tree-level masses due to underlying symmetry and a choice of field content. Unprotected by symmetry, the remaining fermions acquire non-vanishing masses through the quantum corrections induced by the gauge bosons of broken $\mathrm{SU}(3)_\mathrm{F}$. We show that inter-generational hierarchy between the masses of the first two families arises if the flavour symmetry is broken with an intermediate $\mathrm{SU}(2)$ leading to a specific ordering in the masses of the gauge bosons. Based on this scheme, we construct an explicit and predictive model and show its viability in reproducing the realistic charged fermion masses and quark mixing parameters in terms of not-so-hierarchical fundamental couplings. The model leads to the strange quark mass $m_s \approx 16$ MeV at $\mathrm{M_Z}$ which is $\sim 2.4\sigma$ away from its current central value. Large flavour violations are a generic prediction of the scheme which pushes the masses of the new gauge bosons to 10^3 TeV or higher.

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(Gurucharan Mohanta, Ketan M. Patel)

Quantum corrections and the minimal Yukawa sector of SU(5)

It is well-known that the $\mathrm{SU}(5)$ grand unified theory, with the standard model quarks and leptons unified in $\overline{5}$ and 10 and the electroweak Higgs doublet residing in 5 dimensional representations, leads to relation, $\mathrm{Y}_d = \mathrm{Y}_e^\mathrm{T}$, between the Yukawa couplings of the down-type quarks and the charged leptons. We show that this degeneracy can be lifted in a phenomenologically viable way when quantum corrections to the tree-level matching conditions are taken into account in the presence of one or more copies of gauge singlet fermions. The 1-loop threshold corrections arising from heavy leptoquark scalar and vector bosons, already present in the minimal model, and heavy singlet fermions can lead to realistic Yukawa couplings provided their masses differ by at least two orders of magnitude. The latter can also lead to a realistic light neutrino mass spectrum through the type I seesaw mechanism if the colour partner of the Higgs stays close to the Planck scale. Most importantly, our findings demonstrate the viability of the simplest Yukawa sector when quantum corrections are considered and sizeable threshold effects are present.

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(Ketan M. Patel, Saurabh K. Shukla)

Soft supersymmetry breaking as the sole origin of neutrino masses and lepton number violation

We discuss a scenario in which the supergravity induced soft terms, conventionally used for breaking supersymmetry, also lead to non-zero Majorana neutrino masses. The soft terms lead to the spontaneous violation of the lepton number at the gravitino mass scale $m_{3/2}$ which in turn leads to (i) the Majorana masses of $\mathcal{O}(m_{3/2})$ for the right-handed neutrinos and (ii) the R-parity breaking at the same scale. The former contributes to light neutrino masses through the type I seesaw mechanism, while the latter adds to it through neutrino-neutralino mixing. Both contributions can scale inversely with respect to $m_{3/2}$ given that gaugino and Higgsino masses are also of order $m_{3/2}$. Together, these two contributions adequately explain observed neutrino masses and mixing. One realization of the

scenario also naturally leads to a μ parameter of $\mathcal{O}(m_{3/2})$. Despite the lepton number symmetry breaking close to the weak scale, the Majoron in the model exhibits very weak coupling to leptons, satisfying existing constraints on Majoron-lepton interactions. The right-handed neutrinos in the model have a large coupling to Higgsinos. This coupling and the relatively large heavy-light neutrino mixing induced through the seesaw mechanism may lead to the observable signals at colliders in terms of displaced vertices.

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(Anjan S. Joshipura, Ketan M. Patel)

Phase-dependent charge and heat current in thermally biased short Josephson junctions formed at helical edge states

It has been shown in the literature that a significant amount of thermoelectric current can be generated just by tuning the phase difference in any long Josephson junction. This study shows that the charge and heat current in short Josephson junctions (JJs) can be induced when two normal metal regions are attached at opposite ends and the whole junction is formed at the helical edge states of two-dimensional topological insulators. For all finite phases, an asymmetry around the zero energy appears in the transmission spectra except the time-reversal symmetric phases. It is shown that in short junctions when subject to a temperature gradient, the phase-tunable asymmetry around the zero energy is not sufficient to induce a dissipative thermoelectric current in the junction. This is in contrast to the behavior of long Josephson junction, as shown in the literature. The phase-tunable heat currents are obtained with amplitudes set by the phase difference, base temperature, and system size.

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(Paramita Dutta)

Nonlocality of Majorana bound states revealed by electron waiting times in a topological Andreev interferometer

We show how the analysis of statistical distributions like electron waiting times and the correlation between them help in understanding properties of unconventional superconductors. We consider an Andreev interferometer where a superconducting loop with a controllable phase difference is connected to a quantum spin Hall edge. The edge state helicity enables the transfer of electrons and holes into separate leads controlled by the phase difference of the loop. In this setup, the topological phase transition with emerging topological bound states occurs at a particular phase and electron waiting times are sensitive to it. However, the waiting times for the Andreev-reflected holes remain insensitive. These two different waiting times show opposite behaviors when we consider the correlation between them. Some of the cross-distributions also show unique features indicating the appearance of topological Andreev bound states.

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This work was done in collaboration with Jorge Cayao and Annica M. Black-Schaffer of Uppsala University, Sweden and Pablo Burset of Autonomous University of Madrid, Spain.

(Paramita Dutta)

Jet-veto resummation

Vetoing energetic jet activity is a crucial tool for suppressing backgrounds and enabling new physics searches at the LHC, but the introduction of a veto scale can introduce large logarithms that may need to be resummed. We present an implementation of jet-veto resummation for color-singlet processes at the level of $\mathrm{N^3LL}_p$ matched to fixed-order NNLO predictions. Our public code MCFM allows for predictions of a single boson, such as Z/γ^*, $\mathrm{W}^\pm$ or H, or with a pair of vector bosons, such as $\mathrm{W}^+\mathrm{W}^-$, $\mathrm{W}^\pm\mathrm{Z}$ or ZZ. The implementation relies on recent calculations of the soft and beam functions in the presence of a jet veto over all rapidities, with jets defined using a sequential recombination algorithm with jet radius R. However one of the ingredients that is required to reach full $\mathrm{N^3LL}$ accuracy is only known approximately, hence $\mathrm{N^3LL}_p$. We describe in detail our formalism and compare with previous public codes that operate at the level of NNLL. Our higher-order predictions improve significantly upon NNLL calculations by reducing theoretical uncertainties. We demonstrate this by comparing our predictions with the ATLAS and CMS results.

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This work was done in collaboration with John M. Campbell of Fermilab, USA and R. Keith Ellis of IPPP, Durham University, UK and Tobias Neumann of Brookhaven National Laboratory, USA.

(Satyajit Seth)

Identification of 3^{rd}-generation scalar leptoquarks

We explore the pair production of third-generation scalar leptoquark at the Large Hadron Collider to next-to-leading order accuracy in QCD, matched to parton shower for a precise probing of the stemming model. We propose to tag two boosted top-like fatjets produced from the decay of heavy leptoquarks in association with notably large missing transverse momentum and consider them as the potential signal. Such a signal demonstrates the capability of a robust discovery prospect in the multivariate analysis with different high-level observables, including jet substructure variables. Various scalar leptoquark models predict different chirality of the top quark appearing from the decay of the leptoquark carrying same electromagnetic charge. We make use of the polarization variables sensitive to the top quark polarization in order to identify the underlying theory.

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(Anupam Ghosh, Partha Konar, Debashis Saha, Satyajit Seth)

Two-species k-body embedded Gaussian unitary ensembles: q-normal form of the eigenvalue density

Eigenvalue density generated by embedded Gaussian unitary ensemble with k-body interactions for two species (say π and ν) fermion systems is investigated by deriving formulas for the lowest six moments. Assumed in constructing this ensemble, called EGUE(k : $\pi\nu$), is that the π fermions (m_1 in number) occupy N_1 number of degenerate single particle (sp) states and similarly ν fermions (m_2 in number) in N_2 number of degenerate sp states. The Hamiltonian is assumed to be k-body preserving (m_1, m_2). Formulas with finite $(\mathrm{N}_1, \mathrm{N}_2)$ corrections and asymptotic limit formulas both show that the eigenvalue density takes q-normal form with the q parameter defined by the fourth moment. The EGUE(k : $\pi\nu$) formalism and results are extended to two species boson systems. Results in this work show that the q-normal form of the eigenvalue density established only recently, by PRL scientists and their collaborators, for identical fermion and boson systems extends to two species fermion and boson systems.

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(V.K.B. Kota)

Large-scale shell model study of two-neutrino double beta decay of ^{82}Se, ^{94}Zr, ^{108}Cd, ^{124}Sn, ^{128}Te, ^{130}Te, ^{136}Xe, and ^{150}Nd

Large-scale shell-model calculations have been performed for the study of two neutrino double-beta ($2\nu\beta\beta$) decay of medium-mass nuclei (^{82}Se, ^{94}Zr, ^{108}Cd, ^{124}Sn, ^{128}Te, ^{130}Te, ^{136}Xe, and ^{150}Nd). Employed is 'jun45' interaction to calculate the nuclear matrix element (NME) for $2\nu\beta\beta$ decay in ^{82}Se. In the case of ^{94}Zr, the 'glekpn' effective interaction is used. For ^{108}Cd, used is a realistic effective interaction derived through the G-matrix approach. In the case of ^{124}Sn, ^{128,130}Te and ^{136}Xe, the 'sn100pn' effective interaction is employed. For ^{150}Nd, used is 'KHHE' effective interaction based on holes in a ^{208}Pb core. With these, extracted the half-lives of these nuclei in the $2\nu\beta\beta$ decay with the help of calculated NME and the results are consistent with the available experimental half-lives. The variation of cumulative $2\nu\beta\beta$ NME with respect to the excitation energy of the intermediate 1^+ states is also studied, and in all cases, it is ensured that their values are almost saturated. In the present work included are more intermediate 1^+states as much as possible in comparision to results abailable in literature.

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(V.K.B. Kota)

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145. Kiran and R. P. Singh, "Mesospheric Dynamics: Insights from the PRL Airglow InfraRed Spectrograph (PAIRS) over Ahmedabad, India", 22^{nd} National Space Science Symposium (NSSS-2024), 26 February - 01 March, 2024, Presented By: Ravindra Pratap Singh.

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148. K. Venkatesh, D. Pallamraju, T. K. Pant and P. Suryawanshi, "Parametric dependence of topside ionospheric scale height in NeQuick2 model and its consequences on the estimation of TEC over the equatorial and low latitudes", 22^{nd} National Space Science Symposium (NSSS-2024), 26 February - 01 March, 2024, Presented By: K. Venkatesh.

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155. Goyal S. K., "Configuration, on - board performance and initial observations from ASPEX STEPS onboard Aditya L1", 22^{nd} National Space Science Symposium, 26 Feb-1 March 2024, Presented By: Goyal S. K..

156. Goyal S. K., "Design & Characterization of Front End Electronics for Silicon Photomultiplier for imaging of hard X-rays using NaI (Tl) scintillator", 8^{th} IEEE Electron Devices, Technology and Manufacturing, Bangalore, 3-6 March 2024, Presented By: Goyal S. K..

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158. Wafikul Khan, R Ramachandran, S Gupta, J K Meka, Anil Bhardwaj, N J Mason, B Sivaraman, "Mid-IR spectroscopy of pure phenylacetylene at low temperature", Meteoroids, Meteors and Meteorites: Messengers from Space (MetMeSS -2023), 1-3 November 2023, Presented By: Wafikul Khan.

159. Arijit Roy, V.S Surendra, M. Ambresh, J. K. Meka, R. Ramachandran, D Sahu, S. Gupta V Jayaram, B.N. Rajasekhar, J Cami, Anil Bhardwaj, N.J. Mason, B Sivaraman, "Shock processing of smaller PAHs", Meteoroids, Meteors and Meteorites: Messengers from Space (MetMeSS -2023), 1-3 November 2023, Presented By: Arijit Roy.

160. R. Ramachandran, A. Corrigan, D. V. Mifsud, S. -L. Chou, Y. -J. Wu, M. Srivastava, B. N. Rajashekar, Anil Bhardwaj, N. J. Mason, B. Sivaraman, "Thermal and electron-induced chemistry of the three-ringed PAH under astrochemical conditions", Meteoroids, Meteors, and Meteorites: Messengers from Space (MetMeSS -2023), 1-3 November 2023, Presented By: Ragav Ramachandran.

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163. Surendra V Singh, J K Meka, Ragav Ramachandran, Arijit Roy, Penelope Wozniakiewicz, Matthias van Ginneken, Luke Alesbrook, M Ambresh, Anil Bhardwaj, Mark J Burchell, Nigel J Mason, B Sivaraman, "Aqueous alteration of carbon due to hypervelocity impacts", 1^{st} Symposium on genesis and evolution of organics in space, 18-20 January 2024, Presented By: Jaya Krishna Meka.

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167. R. Ramachandran, J.K. Meka, K.K. Rahul, W. Khan, J.-I. Lo, B.-M. Cheng, D.V. Mifsud, B.N. Rajasekhar, A. Das, H. Hill, P Janardhan, Anil Bhardwaj, N.J. Mason, and B. Sivaraman, "Discovery of Ozone on Callisto and its implication to the Jovian system", National Space Science Symposium (NSSS 2024), 25 February - 1 March, Presented By: Ragav Ramachandran.

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171. Dr. Prashant Kumar and Ms. Swetapuspa Soumyashree, “Planetary explorations using laser-induced induced breakdown spectroscopy: Detection limits and sensitivity”, National Space Science Symposium (NSSS), Goa University,, 26 Feb - 1 March, 2024, Presented By: Prashant Kumar.

172. Dipen Sahu[1], Sheng-Yuan Liu[2], Naomi Hirano[2], Doug Johnstone[3], Neal J Evans II[4], Ken Tatematsu[5], and the ALMASOP team, “Digging into fundamental processes of star formations inside prestellar cores and its connection with astrochemistry”, National Space Science Symposium (NSSS 2024), GOA UNIVERSITY, 26 Feb - 01 Mar, 2024, Presented By: Dipen Sahu.

Various Events, and Outreach Activities at PRL

Academic Events

Young Scientists/Engineers Conclave

On May 26, 2023, an exciting and intellectually stimulating event took place at the K R Ramanathan Auditorium at the Physical Research Laboratory (PRL). The One-Day Young Scientist/Engineer Conclave brought together a group of talented individuals who have joined PRL as Scientist/Engineer-SC and Scientist/ Engineer-SD in the last decade, starting from 2013 onward. The conclave, provided a platform for these young scientists and engineers to showcase their research, share their findings, and discuss their future plans. It served as an opportunity for them to interact with each other, exchange knowledge, and foster collaboration within the scientific community at PRL.

Outreach Events/visits

YuViKA Students Visits to PRL

In a captivating event on the 17th of May 2023, 53 bright and aspiring students visited PRL under the esteemed Yuva Vigyani Karyakram (YUVIKA) 2023, aimed to foster scientific curiosity and provide young minds with an opportunity to delve into the world of research. Guided by PRL's accomplished scientists and researchers, the students were immersed in a world of interactive sessions, informative demonstrations, and engaging discussions. They were treated to firsthand experiences of experimental setups, state-of-the-art instruments, and advanced technologies employed within the laboratories. PRL's experts generously shared their knowledge, igniting the students' curiosity and inspiring them with their unwavering passion for scientific inquiry.

World Space Week 2023 celebration at the USO

The World Space Week was celebrated at USO on 10 Oct 2023 with 35 participants from 11 schools, including teachers and students. They were introduced to the solar physics through a broad powerpoint presentation and were shown various observing facilities like the Global Oscillation Network Group (GONG), CALLISTO Radio Telescope at office and also Multi Application Solar Telescope (MAST), SPAR Telescope at island observatory. A Quiz contest, in multiple choice questions format, on the topic General Physics and Space Science Awareness was carried out for the students. The programme is concluded with prize distribution in the Quiz contest.

National Science Day 2024 Celebrations

National Science Day (NSD) in India is celebrated each year to mark the discovery of the RamanEffect. The primary focus of the NSD celebration is science popularization. To mark this day, the Physical Research Laboratory celebrated NSD on March 6th, 2024. In Phase I, the screening tests for the Aruna Lal Scholarship (ALS) and the Vikram Sarabhai ProtsahanYojana (VIKAS) Scholarship were conducted at 21 centers in Gujarat. In Phase II, the students shortlisted from the screening exam were invited to visit PRL to participate in various competitions on Wednesday, March 6 th, 2024. The top 17 selected students were interviewed for the Aruna Lal Scholarship by a panel of experts. Over 154 students and 70 teachers/accompanying parents visited PRL on this day. The 10th PRL Amrut Rajbhasha Vyakhyan (PARV) was organized on this day and Prof. H.C. Verma delivered a talk on *shiksha kshetra me mere prayog*" About 550 people attended this talk offline and on YouTube. The students, teachers, and accompanying parents enjoyed the activities and actively participated, making for a successful and enjoyable celebration of National Science Day.

PRL's Exhibition at NSSS-2024, Goa University

The National Space Science Symposium (NSSS)-2024 was organized at Goa University, Goa, during 26 February-1 March 2024. An exhibition center/stall was set up by PRL during the entire symposium period. A total of 9 posters on frontline research activities, including both ongoing and future programs of various science and Research and Development (R&D) projects, use of quantum technologies being undertaken in different divisions of PRL were displayed. A continuous onsite screen display (Audio + Video-setup, movies) about the history and evolution of research programs at PRL, landmark achievements, glimpses of laboratory experiments, contributions to space programs, etc. was also arranged. In addition, PRL brochures, key rings, stickers, and leaflets on various frontline research programs/projects (such as the VOC Atmospheric Laboratory, Indian Lidar Network Programme, Solar X-ray Monitor (XSM), Alpha Particle X-ray Spectrometer (APXS), Aditya Solar Wind Particle Experiment (ASPEX), Indian Planetary Science Association (IPSA), PRL booklet, Compound Astronomical Low cost Low frequency Instrument for Spectroscopy and Transportable Observatory (CALLISTO), Global Oscillation Network Group (GONG), Multi-Application Solar Telescope (MAST), Chandras Surface Thermophysical Experiment-ChaSTE). etc. were distributed. Several of PRL faculty & staff members, postdoctoral fellows, and research fellows participated and took responsibilities of the exhibition booth from 9 AM to 7 PM throughout the 5 days to interact with not only the delegates of the NSSS-2024 visiting our stall but also the host of visitors, school and college students, parents, who had come in large numbers. PRL sincerely thanks the NSSS-2024 Local Organizing Committee (LOC) and Faculty & Staff members of Goa University for providing the space and other facilities to set up an exhibition stall.

PRL's participation in COLAB, IIT Gandhinagar

IIT Gandhinagar (IITGN) organized the academic-industry meet

('Colab 2024'), an open House event that was held on 02 March 2024. This event aimed to foster sustainable industry-academia collaborations. Many young researchers, entrepreneurs, and academic and industry experts interacted and shared their ideas. Over 150 academic and industry participants from diverse domains participated in this event. During the event, several parallel panel discussions also took place, each focusing on specific domains such as space tech, climate challenges and solutions, artificial intelligence (AI) and computing, biomedical engineering, healthcare and pharmaceuticals, manufacturing, energy and water, and defense.

PRL actively participated in this event. The PRL team presented the PRL activities with experimental models, payloads, and posters of each scientific division. Over 100 participants visited PRL's stall and interacted with PRL teams. PRL team members also visited to other stalls and research park of IITGN and benefited from the event.

Celebration of days/weeks and months

Celebration of Ambedkar Jayanti

The 132nd Birth Anniversary of Bharat Ratna Dr. B R Ambedkar was celebrated at Reserved Class Employees Association Office at PRL Main Campus and Udaipur Solar Observatory, PRL. The programme started with the lighting of Diya, floral tribute to the great sculptor of Indian Constitution. Director, PRL spoke about the work of Dr. Ambedkar for upliftment of socially and economically backward class and women empowerment. Registrar, spoke about the dedication and contribution of Dr. Ambedkar to the country.Dean, PRL spoke about the belief and great vision of the Dr. Ambedkar. Liaison Officer for SC/ST/PWD and Liaison Officer for OBC also shared their thoughts on the auspicious occasion. The programme was coordinated by PRL Reserved Class Employees Association. In the program, Dr. TC Damor, IPS - 1994 batch, former S.P. - Chittorgarh, Rajasthan, former IG - Anti-Corruption Bureau, former IG - Udaipur, former Vice Chancellor (First Vice Chancellor) - Rajiv Gandhi Tribal University, Udaipur, delivered a popular lecture on the topic Contribution of Dr. B.R. Ambedkar in Nation Building.

National Fire Service Week

As a part of Fire Service Week and considering the vitality of sensitizing PRL members, a mock drill simulated training on Fire incident/accident scenario was conducted at PRL Main campus and at thaltej campus on Tuesday, 18th April, 2023. During the programme, Shri. Ramesh Kumar, Inspector, CISF explained about different types of fire, causes and prevention factors related to fire. He has further narrated about the types of extinguishers used in the premises their applicability as per the type of fire. The practical demonstration was also given by the CISF team on how to use these extinguishers to control the fire and save the human and materials nearby. As a part of this celebration a mock drill simulated training on Fire incident/accident scenario was conducted. Around 160 PRL members attended the mock drill & fire event demo activities.

Celebration of International Day of Yoga-2023

As a part of Azadi Ka Amrit Mahotsav, the 9th International Day of Yoga (IDY-2023) was celebrated on 21 June 2023 (Wednesday) at Ahmedabad, Mt. Abu and USO campuses of PRL.

Special Lecture on Health & Sanitation under SwPC

As a year long activity under Swachhta Pakhwada-2023, a lecture was arranged for contractual staff members of PRL and their family members to make them aware of the routine Health and Sanitation. The Lecture was delivered by PRL Medical Officer Dr. Shital Patel on 10.05.2023 (Wednesday) at the PRL Main Campus and on 12.05.2023 (Friday) at PRL Thaltej. The main focus of the talk was on Hygiene and Sanitation and giving up bad habits like Tobacco etc. The importance of personal hygiene was also emphasized during the lecture to them. The programme ended by taking Swachhta Pledge.

World Environment Day - LiFE Campaign Pledge

As per the Government of India, Department of Space directive, all the employees of Central Government/ Departments/ State Governments/ Training Institutes were advised to take pledge on Mission LiFE on World Environment Day i.e. 5th June, 2023. PRL members celebrated World Environment Day on Monday, 5th June, 2023 at 1100 hrs by taking pledge on Mission LiFE at their respective work place. Alongwith this, DoPT had enabled a provision on e-HRMS (https://e-hrms.gov.in) to facilitate Central/ State Government employees to take LiFE pledge online and download their certificates. To earmark the occasion, tree plantation was done by the Director, PRL, Dean PRL, Registrar, PRL and other PRL members.

Vikram Sarabhai Jayanti celebrations at PRL

Every year PRL celebrate Vikram Sarabhai Jayanti on 12th August in all the campuses of PRL. This year PRL celebrated the 104th Birth Anniversary of Prof. Vikram Sarabhai, who is the father of Indian Space Programme and founder of Physical Research Laboratory (PRL), a function was organised in his remembrance at PRL Main and PRL Thaltej Campus. The function started at PRL Main campus by garlanding the statue of Prof. Vikram Sarabhai by Sarabhai family members along with other dignitaries. Thereafter, a tree plantation was organised at both Main campus and thaltej campus. The function concluded as per PRLs tradition of distributing Churma Ladoos (made at PRL canteen) to mark the Birth Anniversary of Prof. Vikram Sarabhai in both capuses.

77^{th} Independence Day celebration at PRL, Ahmedabad

The 77^{th} Independence Day was celebrated with the great enthusiasm at PRL Main campus and Udaipur Solar Observatory on 15th August 2023 (Tuesday) under the Azadi Ka Amrit Mahotsav.Director, PRL hoisted the National flag, which was followed by the National Anthem. As per protocol, CISF, PRL personnel carried out a Parade. Director, PRL had delivered an enriching and patriotic speech to the audience, showcasing PRLs Scientific & other activities undertaken during the year. This was followed by merit and service awards to CISF Cadets. Thereafter, the prizes were distribution for various competitions that held under the AKAM. Tri-color balloons were also released by the children to mark the day of Independence followed by the tree plantation by PRL members and their family members.

"Hamara Kaarya" Competition at USO/PRL, Udaipur

On the occasion of Hindi Maah, PRL Hindi Maah committee team arranged various competitions as part of the Hindi month 2023. Hamara Kaarya competition was organized by Udaipur Solar Observatory, Physical Research Laboratory, Udaipur. The said competition was organized on 6th October 2023 in the Main office campus of USO/PRL, Udaipur. The main objective of this competition

was to get acquainted with the important work / activities in nut shell of other member offices under Town Official Language Implementation Committee, Udaipur. %In his Inaugural address Dr. Anil Bhardwaj, Director, PRL greeted all the dignitaries, participants and members of USO. The Director, PRL also offered his best wishes to TOLIC, Udaipur and USO/PRL, Udaipur for conducting such programme. In the said competition, participants from ten (10) member offices of TOLIC, Udaipur participated. The participants presented the major chores / activities of their office by using PowerPoint slides of 8 minutes duration followed by 2 minutes question & answer round in Hindi language. The presentation of the participants were evaluated by a panel of distinguished judges comprises of 1. Shri Giriraj Paliwal, Secretary, TOLIC, Udaipur 2. Mrs. Anju Beniwal, Asst. Professor, Meera Girls College, Udaipur, and 3. Dr. Ankala Raja Bayanna, Scientist/Engineer-SF, Udaipur Solar Observatory, Udaipur The evaluation criteria was based on four (4) parameters a. Subject Matter b. Language c. Presentation style d. Time management The said programme is also got appreciation during the half yearly Meeting of Town Official Implementation Committee, Udaipur as this was the first time where various offices got a platform to showcase their work.

Vigilance Awareness Week 2023

Based on the Circular of Central Vigilance Commission (CVC) dated 11.09.2023 and DOS endorsement thereon dated 14.09.2023, the Vigilance Awareness Week (VAW) 2023 was observed in PRL from 30th October 2023 to 5th November 2023. The theme of the VAW-2023 was ”Say no to corruption; Commit to the Nation“. All the staff Members of PRL took Integrity Pledge at their respective work places on 30.10.2023. Apart from Integrity Pledge, all staff members were encouraged to take Integrity E-pledge in CVC portal (https://pledge.cvc.nic.in).

Garba celebration at PRL-2023

Navratri, literally meaning ”nine nights,” is the festival dedicated to Durgathe feminine form of divinity and her nine forms. This festival is observed in many ways, each unique to the region of India in which it is celebrated. Garba is performed during Navratri, the longest and largest dance festival in the world. Garba celebration was organized at PRL Thaltej Campus on 27.10.2023 by Staff Welfare Committee. The PRL members with their family participated in garba dressed in traditional Garba ensembles. The celebration started by offering prayers to Goddess Navdurga and then by performing Garba. Everyone was seen dancing and enjoying themselves out to the tunes of Garba.

National Unity Day 2023

National Unity Day is an initiative celebrated every year to commemorate Sardar Vallabhbhai Patels birth anniversary. In PRL the celebration of national unity day started with a pledge taking ceremony that embarked the spirit of unity among everyone. Further, to earmark the birth anniversary of Sardar Vallabhbhai Patel and National Unity Day, the Unity/Ekta Rally was organised at PRL Main campus starting from K. R. Ramanathan Auditorium to Vikram Sarabhai statue at main gate and back to the Administration lawn. Every PRL members actively joined this Ekta rally, a few holding national flags too. This significant program engraved the spirit of Ekta amongst all the PRL members.

Death Anniversary of Late Prof. Vikram A Sarabhai and Late Prof. K R Ramanathan

On the solemn occasion of the 30th of December 2023, marking the death anniversary of the esteemed founder of the Physical Research Laboratory, Late Professor Vikram A. Sarabhai, and the subsequent day, the 31st of December 2023, commemorating the death anniversary of the founding Director of PRL, Late Professor K.R. Ramanathan, a heartfelt homage was extended to these distinguished scientific pioneers. This reverential tribute held at the Foyer area of the K.R. Ramanathan Auditorium on Friday, the 29th of December 2023. The portraits of Professor Vikram A. Sarabhai and Professor K.R. Ramanathan were adorned with garlands, and a lamp was lit in their memory, symbolizing the enduring light of their contributions to science. During the ceremony, Director, PRL addressed PRL members, eloquently highlighting the profound scientific legacies left by both Professor Vikram A. Sarabhai and Professor K.R. Ramanathan.

Constitution Day 2023

The government of India has decided that Constitution Day would be celebrated every year to commemorate the day of adoption of our constitution. The Constitution Day was celebrated in PRL on Friday, 24th November 2023 (25th- 26th November being weekend) On this occasion, the ”PREAMBLE OF THE CONSTITUTION was read by all the PRL members in K.R. Ramanathan Auditorium.

Swachhta Pakhwada 2024

The Swachhta Pakhwada was celebrated at Physical Research Laboratory (PRL) from February 1st to 15th, 2024, as per the directives received from Director CEPO/ Nodal Officer, SAP on ”Swachhta Action Plan 2024”, which states that ”Swachhta Pakhwada” is to be organized from February 1st to 15th, 2024 in the Department of Space and DOS Centres/Units with the main focus on ”Swachhta everyones business”. PRL members took the Swachhta Pledge as part of the Swachhta Pakhwada on February 1, 2024. An online quiz competition was held to celebrate Swachhta Pakhwada 2024. Employees and contractual workers participated in Swachhta Rally drives at the PRL Main Campus, Thatlej Campus, USO Campus and MIRO Campus. Swachhta Signature Campaigns were held at PRL Main Campus and Thaltej Campus. A drawing competition was organized at Vinoba Bhave Municipal Saraswati Mandir. We conveyed and promoted awareness among the school children about the significance of cleanliness and hygiene. Further, jute bags were distributed to them. To ensure cleanliness and hygiene, water tanks, sewage lines, and artificial ponds at office campuses and residential colonies were cleaned on a regular basis. Fogging and fumigation were carried out as part of the Swachhta Pakhwada Campaign during the Pakhwada season on all PRL campuses and residential colonies. Furthermore, it would be a regular interval year-round scheduled activity. PRL is committed to promoting and disseminating information on cleanliness, hygiene, and sanitation. We emphasize maintaining a clean and green environment at PRL's campuses. We believe that a clean and healthy environment is essential for the well-being of every human being. Our devotion to cleanliness extends beyond the physical infrastructure of our campuses. PRL members are equally devoted in fostering cleanliness in their personal and professional life.

Societal services

Influenza Vaccination Camp 2023

Every year Dispensary PRL organizes influenza vaccination camp for the CHHS beneficiaries. The influenza vaccination camp was held at Dispensary Navrangpura PRL on 30.10.2023 and 31.10.2023. The beneficiaries were given Tetravalent Flu vaccine (Vaxiflu-4). Total 250 beneficiaries were covered under Anti-flu vaccination during this camp.

Blood Donation Camp Held on 15.06.2023 at PRL Dispensary

The Blood Donation Camp held at PRL Dispensary on 15th June 2023, in observance of "World Blood Donor Day," was a resounding success. The Blood Donation Camp witnessed an overwhelming response, with a total of 50 participants, including Director, Registrar, Faculty members, Staff members, and a significant number of students came forward to donate blood. The selfless act of voluntary blood donation exemplifies compassion, empathy, and a genuine concern for the well-being of others.PRL is immensely proud of each of the donors who made invaluable contribution to this noble cause and extends its heartfelt gratitude to all the donors for their unwavering support and enthusiasm. It is through such acts of kindness and solidarity that we can create a healthier and more caring society.

School Bag and Pencil box distribution for Girl child of contractual workers

In order to promote the thought of Beti Padhao, an encouraging initiative was suggested by the Director, PRL to distribute the bags to contractual workers, having second child as Girl child. The above event was organized on Thursday, 1st June, 2023 at PRL Reserved Class Employees Association office. Head, P&GA and Head, Accounts & IFA were present on this occasion. They had distributed the bags to the contractual workers, having second child as Girl child. Head, Accounts & IFA addressed the crowd and encouraged them to motivate their girl child for education for better future.

Bag Distribution to PRL Contractual Workers

Bag Distribution to PRL Contractual Workers With kind guidance and support of the Director, PRL, the distribution of the school bags and pencil boxes were organized by PRL Reserved Class Employees Association on various dates as on 27.02.2023 and 27.03.2023 at PRL Main Campus and on 18.04.2023 at PRL Thaltej Campus. During these events, school bag and Compass Box were distributed to the contractual workers of PRL i.e. daily-wages/ shifting, house-keeping, canteen, horticulture, contractual drivers and contractual security guards.

School Bag and Compass Box distribution to School Students at Behrampura Primary School

As part of celebration of Ambedkar Jayanti (2022) and with kind guidance and support of the Director, PRL, an event of distribution of School Bags and Compass Boxes to the Students of class 6th to 8th standards of Behrampura Primary School No.22 which runs by Ahmedabad Municipal Corporation Board was organized on 25.01.2023.

Sports Activities

National Sports Day - FIT India Fitness pledge

As per the Government of India, Department of Space directives, the National Sports Day 2023 was celebrated during 21st August to 29th August, 2023. As a part of this, a FIT India Fitness pledge was taken by the PRL members on Monday, 28th August, 2023 at respective work place at 1100 hours. PRL Members were also encouraged to take the FIT India pledge on https://pledge.mygov.in/fitindia/ and to download certificate.

PRL Cricket League (PCL-2023)

Physical Research Laboratory, Ahmedabad has organized the first Inter Area/Division Cricket Tournament PRL Cricket League -2023 (PCL-2023) from 22nd April to 30th April 2023 under the celebrations of Azadi Ka Amrit Mahotsav. A total of seven 7 teams (i.e. PSDN, ASTAS, SPASC, GSDN, AMOPH, THEPH, and [Admin + Services]) participated in this tournament.

Vikram Sarabhai Space Cup 2023

The Vikram Sarabhai Space Cup football tournament, organised by the Space Applications Centre, commenced on 15th April 2023 at the prestigious Vikramnagar Football Ground, Vikramnagar Colony. The tournament brought together six prominent teams representing different organisations and institutes, adding an extra layer of competitiveness and prestige to the event. The participating teams included the Physical Research Laboratory, Space Applications Centre A, Space Applications Centre B, Institute of Plasma Research, Indian Institute of Technology Gandhinagar, and the Oil and Natural Gas Corporation.

Tug Of War

As a part of Azadi Ka Amrit Mahotsav, an Inter Division/Area Tug of War Competition was organized at PRL Library Lawn at PRL, Ahmedabad on 11th August, 2023 (Friday). Division /Area wise team of 8 members were formed. Four teams namely Team Ahilya, Team Kalpana, Team Teresa and Team Lakshmi were also formed comprising Female staff members. Everyone had enjoyed the event thoroughly.

Inter Centre Sports Meet (ICSM)

National Remote Sensing Centre Hyderabad has hosted Inter Centre Sports Meet (ICSM) in Hyderabad The event unfolded across two phases, each contributing to the vibrancy of the overall experience. Phase I: Outdoor Games (16.11.2023 to 20.11.2023) saw the active participation of 14 dedicated members from PRL (including contingent manager) showcasing their prowess in Athletics, Track and Field. Meanwhile, Phase II: Indoor Games (23.11.2023 to 26.11.2023) witnessed a robust contingent of 28 members, (including 1 Contingent Managers), competing fervently in Table Tennis, Badminton, Chess, Carom, and Bridge. The spirited PRL contingent not only exhibited athleticism but also demonstrated a remarkable spirit of unity and sportsmanship, reflecting the core values inherent in such collaborative events.

PRL-ICC events

PRL-ICC Orientation Program at PRL USO

An Orientation Program for all female members of USO was held by Internal Committee (PRL-IC) in PRL, Udaipur Solar Observatory,

Udaipur on 16th October 2023. Chair, IC delivered a Talk regarding different issues related to IC and guided the female employees about functioning of IC. After he talk a senitization realted session was also held for all the employees of USO and different topic related to workplace behavoiur is discussed. At the end of Session new brochures 2023 were distributed with complete details of members and regarding zero tolerance towards sexual harassment in PRL.

Program organized by PRL-ICC regarding Prevention of Sexual Harassment Act-PoSH 2013

A program was organized by the Internal Committee at Physical Research Laboratory, Ahmedabad on 11th December, 2023 to mark the historic judgement of Prevention of Sexual Harassment Act-PoSH 2013 and its 10th anniversary. The program started with the speech of Chair, IC who informed all the members about PoSH Act-2013. After this, the Director, PRL delivered the welcome speech and made everyone aware about keeping the workplace environment fear-free and friendly to all the employees. The Speaker of this program was expert PoSH trainer Dr. Krishna Bipin Mehta spoke about the sexual harassment at workplace and the importance of Internal Committee formed to report such incidents. The program ende with distribution of prizes to the winners of an ”Online Quiz competition” that was organized by the Internal Committee of PRL and The vote of thanks.

Capacity Building Programmes

USO/PRL Solar Physics Workshop [USPW-2023]

"USO/PRL Solar Physics Workshop [USPW-2023]", A three-day USO/PRL Solar Physics Workshop [USPW-2023] on "Multi Scale Phenomena on the Sun: Present Capabilities and Future Challenges" was completed successfully between 03-05 April, 2023 at the Udaipur Solar Observatory. The program was inaugurated by Padma Shri Shri. A. S. Kiran Kumar, Chairman PRL, Council of Management. On this occasion, Prof. Anil Bhardwaj, Director, PRL, greeted all the visiting scientists with his welcome address. He briefed about the purpose of this workshop to bring all the present solar scientists on a single platform for discussion on current solar research topics. The chief guest of the inauguration ceremony, Shri. A. S. Kiran Kumar addressed all the scientists and emphasized on the fact that new dimensions and new results of research can be obtained through scientific observations and information, along with innovative techniques such as artificial intelligence and machine learning. For this purpose, he focused on the necessity for a conducive environment in the country. In the end, he inspired the scientists to prepare the outline of the upcoming solar mission through this workshop.

In the three days workshop, different researchers from across the country discussed various aspects of solar observations and computer simulations to understand those observations. In the workshop several presentations were made followed by discussions on future space solar missions of India. Focus was put on India's capabilities to understand various solar phenomena. In the workshop total 23 invited talks, 12 solicited talks and 20 posters were presented, and in total almost 80 participants attended the workshop.

On the concluding day of the Udaipur Solar Physics Workshop on Multi-scale Phenomena on the Sun: Present Capabilities and Future Challenges, the focus was on the upcoming Aditya-L1 payloads: VELC, SUIT, ASPEX, PAPA, and MAG. Various principal and co-principal investigators of these payloads discussed their scientific objective and instrumental capabilities. At the end of the session, intense discussions were made on the prospective observational requirements of the solar physics community. It was decided that the delegates will mutually prepare a vision document within a given time frame which will be submitted to the Director, Physical Research Laboratory. The workshop was concluded by Prof. Anil Bhardwaj, Director, Physical Research Laboratory, who advised the solar physics community to organize another workshop, preferably international, in the time between the launch of the Aditya-L1 mission and its insertion in the L1 orbit.

1st Winter School in Solar Physics at USO-PRL

The 1st Winter School in Solar Physics was held at the Udaipur Solar Observatory, PRL from 4th to 8th December 2023. A total of 35 students representing 16 Universities and Colleges all across India attended the School. The list of Institutions were as follows University of Kerala (Trivandrum Kerala), Calicut University (Kozhikode Kerala), St. Jospehs College (Trichy Tamil Nadu), Loyola College (Chennai Tamil Nadu), Andhra University (Visakhapatnam Andhra Pradesh), Utkal University (Bhubaneswar Odisha), Pt. Ravishankar Shukla University (Raipur Chattisgarh), Fergusson College (Pune Maharashtra), St. Xavier's College (Ahmedabad Gujarat), Maharaja Sayajirao University (Baroda Gujarat), Mohanlal Sukhadia University (Udaipur Rajasthan), Bhupal Nobles University (Udaipur Rajasthan), University of Rajasthan (Jaipur Rajasthan), PG J. P. University (Chhapra Bihar), Manipur University (Imphal Manipur), and Doon University (Dehradun Uttarakhand). Lectures were given on various aspects of Solar Physics which included the Solar Internal Structure, Astronomical and Heliographic Co-ordinate systems, Sunspots, Solar Spectroscopy, Adaptive Optics, Solar Polarimetry, Solar Flares and Eruptions, MHD Simulations of Magnetic reconnection, Coronal Heating Problem, Upper Solar Atmosphere and Solar Wind, and the ASPEX instrument on-board the Aditya-L1 mission of ISRO. In addition to the lectures, hands-on tutorials were also conducted on different aspects of observational techniques. The students were given a tour of the various facilities of USO on the island as well as the office premises. The success of the Winter School provides us with an impetus to conduct this programme annually at USO.

CSSTEAP short course on solar physics

Under the auspices of Center for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) affiliated to the United Nations, an online short course on solar physics has been conducted between 22-26 May, 2023. The objective was to create an understanding of the basics and current research trends in these fields to encourage the young minds toward a career in solar physics. A total of 114 students from 12 different countries including Azerbaijan, Bangladesh, Bhutan, Ethiopia, India, Uzbekistan, Kazakhstan, Malaysia, Myanmar, Nigeria, Philippines took part in the course. The course focused on different topics like Solar structure and dynamics, Solar magnetic field, Solar oscillations, Solar wind, Coronal heatings, Solar eruptive phenomena like Solar flare, CME, Prominence eruption etc and impact of these activities on space weather; augmented with lectures on instrumentations encompassing solar x-ray astronomy, solar radio astronomy, imaging spectroscopy of the sun, tools for practical astronomy etc. Additionally, practicals were also organized to understand the subject more deeply.

Short Course on Isotopes in Nature

A three-day workshop/school Short Course on Isotopes in Nature (SCIN-2024) was organized at Physical Research Laboratory from 7-9 March 2024. The course was designed for students and researchers in their early research career (MSc and early PhD). The course included lectures on the basics of applications of isotopes in probing various earth system processes and their timings. The major objective of the SCIN-2024 was to bring students and

early-career researchers on a common platform to introduce them to various important topics in isotope geochemistry such as the basics of elements/isotopes and applications in the earth sciences, Nucleosynthetic processes, geochronology, radiogenic and stable isotope geochemistry, application of cosmogenic radionuclides and data analysis in Earth Sciences. Visits to various GSDN analytical facilities were also arranged for the course participants. In total, PRL hosted 50 MSc and PhD students from various universities and institutes from all parts of India.

Joint Inaugural Function of CSSTEAP Courses

Under the aegis of the UN-affiliated Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), the 13th Post Graduate Courses on (i) Satellite Meteorology and Global Climate (SATMET-13) and (ii) Space and Atmospheric Science (SAS-13), are being conducted at Space Applications Centre (SAC), Bopal Campus, Ahmedabad during September 1, 2023, to May 31, 2024, by Space Applications Centre (SAC) and Physical Research Laboratory (PRL) respectively. Nineteen participants representing six countries of the Asia Pacific region are attending the Courses. A joint inaugural function of the two courses was held at K. R. Ramanathan Auditorium of PRL on 6th October 2023. Shri Nilesh Desai, Director of SAC, Dr. Anil Bhardwaj, Director of PRL and senior officers from SAC and PRL graced the function. Dr. Arjit Roy, Programme Coordinator of CSSTEAP, Dehradun joined the function online. Dr. Bhardwaj, Shri Desai and Dr. Roy welcomed the participants and presented a brief overview of PRL, SAC and CSSTEAP respectively. The participants gave a brief introduction about themselves.

Lab Visit of CSSTEAP Students

Under the aegis of the UN-affiliated Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), the 13th Post Graduate Course on Satellite Meteorology and Global Climate (SATMET-13) and the 27th Post Graduate Course on Remote Sensing and Geographic Information System (RSGIS-27) are currently being conducted by SAC, Ahmedabad and IIRS, Dehradun respectively. As part of their programme, the students of these courses visited some laboratories at PRL (Main Campus) on 23 November, 2023. At the Aerosol Characterization Laboratory in the Space and Atmospheric Science Division, they were quite interested in knowing what aerosols are and their impact on climate. The different kinds of aerosols and their role in radiative transfer and climate were discussed. The various instruments and techniques deployed to measure aerosol characteristics were demonstrated and explained by Prof. S. Ramachandran, in addition to global model simulations of aerosols and their impact on climate. Questions were asked on global warming and climate change, and the role aerosols play in climate and climate change. At the Geosciences Division, the students were briefed about the activities of the Division by Prof. S. Kumar and Prof. A D. Shukla. After initial interaction, the students were taken to the following 3 laboratories: (a) IWIN Laboratory (water analysis using Isotopic Ratio Mass Spectrometer), (b) GEOSIL Laboratory (Geosciences Stable Isotope Laboratory: Isotopes of C, N, O and S in all types of geological samples), and (c) Thermal Ionization Mass Spectrometer (TIMS) which is used for analysing long-lived radioactive isotopes of Sr, Nd, Pb etc.

Dust EXperiment (DEX) flown on PS4 of PSLV C-58

Dust is a major constituent in any planetary system and it is found everywhere. Over the last couple of decades, there have been remarkable changes in the field of dust science due to in-situ space experiments, the remote sensing and the observations of dusty comets. Present research includes optical and momentum sensing techniques for cometary dust particles, near Earth and interplanetary dust collection and measurements, origin and dynamics of the dust particles found in solar system and many more. The Interplanetary Dust Particles (IDPs) interact with planetary bodies and can affect the ionospheric layer. To study IDP at Venus, the engineering model of Venus Orbiter Dust EXperiment (VODEX) was developed at PRL. To demonstrate the dust detector working in space, a Dust EXperiment (DEX) module was sent off from PRL on 20 December 2023 and finally it was flown on PS4 of PSLV C-58 (XPoSat) on 1st January 2024. The DEX has been found working successfully in the space. It provided observations of IDP impacts in the Earths orbit, at altitude of 350 km. The DEX is a dust detector, which helps in understanding the physical properties of IDPs reaching Earth. It works on the principle of hypervelocity impact ionization. Team: Jayesh Pabari (Principal Investigator), Srirag Nambiar, Sonam Jitarwal, Rashmi, Kinsuk Acharyya, Arpit Patel, Hiteshkumar Adalja, Anil Bhardwaj from PRL; S. M. K. Praneeth, Bhavik Shah, Jaimin Rami, Jaykumar Delvadiya, Deepak Kumar, Pinalkumar Suthar, V. K. Singh, Sandip Somani, Tarun Singh Baghel, Ishwar Lal, Vipul Purohit, Shrikant Patil, Arun Bindal, Sourabh Jain, Rahul Khandekar, Shilpa Pandya from SAC; R. K. Singh from IPR and Team.

Demonstration on the Integration of GEM-COINS System

There was a guidelines by Ministry of Commerce & Industry, Govt. of India to procure material via GeM Portal. To maintain the consistency with our ISRO software, i.e. Cowaa/COINS, Purchase and Stores users has release and maintain Purchase related data in Cowaa/COINS too. ISRO has developed IGIS (ISRO-GeM Interface System) Server. IGIS Server act as a bridge between COINS & GeM Portal and helps to import POs, Invoices, CRAC Bills, etc. released on GeM into COINS. This will reduce redundant work at Purchase and Store Section, ensure data integrity and enhance users efficiency & productivity. A meeting on IGIS Server integration and demonstration was held on July 13, 2023 in CNIT Committee room. The purpose of the meeting was to make aware concerned Cowaa/COINS users from Purchase and Stores about the IGIS

Vikram Discussions VD(I) Astrobiology & Astrochemistry

As a part of national science network building initiation of Physical Research Laboratory, the institute has started Vikram discussions, an annual discussion series to bring together scientists of particular science fields to discuss, debate and design the future course of the community. This discussion series is named after the visionary Dr. Vikram Sarabhai, the founder of PRL and the Indian Space program.

As a suitable tribute to the ideals of Dr. Vikram Sarabhai, the newly formed Interdisciplinary Program for Astrobiology and Astrochemistry (IPAA), PRL, organized the first Vikram Discussion (VD-I) on Astrobiology and Astrochemistry at PRL from 5 6 January 2024.

This was an effort to bring together astrochemists and astrobiologist from across the country to cater the needs of the current and future Indian Space Programs. As it has been often pointed out, there is indeed a dire need to bring researchers of various fields on

a single platform as the interdisciplinary nature of astrobiology & astrochemistry requires the expertise of various fields. To achieve the ambitious goals set by the Indian Space Program, researchers across the disciplines had met and discussed the current status and the efficient way forward by utilizing the resources and facilities available in the country.

International Conference on Planets, Exoplanets, and Habitability (ICPEH-2024)

The Physical Research Laboratory (PRL), Ahmedabad organized the "International Conference on Planets, Exoplanets, and Habitability (ICPEH-2024)" during 5-9 February 2024. This conference provided a platform to promote networking among peers and greatly benefited the early and mid-career researchers, space technologists and innovators, and start-ups.The conference was attended by around 250 delegates from more than 12 countries around the world, with nearly one-third of the conference participants being women scientists. In this conference PRL felicitatated Prof. Michel Mayor (Nobel Laureate) of Geneva Observatory and the and Prof. Carle Pieters of Brown University.

9th Topical conference on Ultrafast Photonics and Quantum Science

The 9th Topical Conference (TC) of the Indian Society of Atomic and Molecular Physics (ISAMP) was held in the Navrangpura campus of PRL, Ahmedabad during 15-17 February 2024. The theme of the conference was Ultrafast Photonics and Quantum Science. This theme was proposed to keep account of ongoing research at PRL and its importance in national and international perspectives. The primary motivation of this conference was to bring researchers from diverse areas of ultrafast photonics, lasers, and quantum technologies on the same platform to cross-pollinate their scientific ideas. Ultrafast photonics topics are related to the study of light and its interaction with matter on short timescales, typically less than a picosecond. This includes investigating processes that occur in atoms and molecules. At PRL, the ultrafast atomic, molecular physics research started in year 2016 by establishing a worldclass Femtosecond laser lab in the Atomic Molecular & Optical Physics Division, although the research on atoms and molecules started in 1970, and the Indian Society of Atomic and Molecular Physics (ISAMP) was registered at PRL in 1981. Thus, PRL has contributed a lot in the field of atomic and molecular physics that has been currently enriched by ultrafast atomic and molecular physics. At PRL research in Quantum Optics was initiated in 1997 by the then Director, PRL, Prof. G. S. Agarwal and now the institute has many groups contributing significantly to the experimental and theoretical Quantum Science and technology. The theme Quantum Science was proposed to bring experts to share their ideas not only on fundamental science but also to discuss Indias National Quantum Mission and how the community could deliver. PRL scientists have already demonstrated the freespace quantum communication for a few hundred meters and now gearing towards Satellite-based quantum key distribution. Laboratory activities are going on towards photonic quantum computing and quantum sensing as well. There is a lab working on defect centres in crystals, which holds great promise for quantum sensing. This prestigious meeting was an opportunity for researchers to interact and share their research experience, and ideas with distinguished scientists working in diverse areas of Ultrafast Photonics and Quantum Science and Technology.

Highlights of the conference

115 participants (35-faculty, 65-Students & Postdoc, 15-corporate participants) from several academic and research institutes, Universities, CSIR labs., IITs, IISER, IIST, and ISRO units attended this conference.

There were ten scientific sessions with 33 talks, including two (2) plenary talks, twenty-six (26) invited talks, four (4) student/contributory talks, one (1) vendor talk, and one (1) colloquium.

There were 49 posters presented in the conference. 5 posters were selected as best posters.

Multiple talks on Ultrafast photonics, attosecond science, Quantum science and technology were presented.

In summary, the 9th Topical Conference on Ultrafast Photonics and Quantum Science was a very successful science event that helped many young researchers who shared their ideas with experts of ultrafast, attosecond, Quantum science, and technology.

The 5th workshop on luminescence dating and its applications (WLDA-2024)

The 5th workshop on luminescence dating and its applications (WLDA-2024) was hosted by the Physical Research Laboratory, Ahmedabad during 21-23 February 2024. A pre-workshop hands-on training session was held at the Institute of Seismological Research (ISR) on 20th February 2024. These were held under the auspices of the Association of Luminescence Dating (ALD). The preworkshop training and workshop received an overwhelming response. The pre-workshop was attended by more than 50 participants. While, more than 120 participants from different parts of the country participated in the workshop at PRL. There were about 20 Keynote lectures on the luminescence basics, advanced methodologies and applications along with several oral talks on interesting research areas of luminescence dating and applications. About 60 students and faculties from different university or institutes of India presented their research work in a vibrant poster session under the themes of Advances in Luminescence Technique: New Signals and Methodology, Fluvial Applications, Glacial Applications, Archaeological Applications, Tectonic Geomorphology and Paleo-Seismology. The posters were designed to highlight the research works and to seek expert advises on use of luminescence for establishing chronology in participants research areas. Several researchers sought the expert advice on possibility of using luminescence for their ongoing or planned research works.

The pre-workshop started with fieldwork in Sabarmati river section, near ISR campus. In this, the geological settings of the river section was discussed by geologists from ISR followed by discussion on sampling methodology, hands on experience of sample collection by participants. Fieldwork was followed by lectures on basics of luminescence technique covering the aspects of physics of luminescence mechanism, luminescence dosimetry, dating, and dose rate estimation for quartz and feldspar by different luminescence experts. The day concluded with long discussions on solving doubts of the participants related to basics of luminescence technique.

4th workshop of International Network in Space Quantum Technologies (INSQT)

The 4th workshop of International Network in Space Quantum Technologies (INSQT) was organized by PRL, Ahmedabad, during

March 20-22, 2024. The INSQT Workshop 4 consolidated the ongoing efforts across various domains in Space Quantum Technology (SQT). The workshop was attended by more than 100 participants, including more than 20 foreign participants from more than 10 countries. The workshop discussed topics ranging from quantum key distribution (QKD) in terrestrial and spacebased systems, quantum clock, remote clock synchronization, continuous variable QKD systems, high-dimensional states for QKD, security analysis of protocols, random-number generators, and several others.

The INSQT is established to bring together the international space quantum community to tackle the engineering challenges and to accelerate the development of quantum space missions. It also aims to establish a roadmap and identify key steps for the space quantum internet. INSQT members include academic and public sector institutions, research organizations, small & medium enterprises (SME), and large companies. There are more than 40 members worldwide. Recognizing the activities in the field of quantum communication at PRL, the institute has been accepted as an academic member of the network. The funding for the network led by the University of Strathclyde, UK, comes through the UK Engineering and Physical Sciences Research Council (EPSRC), and UK Research and Innovation (UKRI).

Two Days Training Programme on Gateway Level Perimeter Network Security device of PRL Computer Networking and Information Technology (CNIT) Division

PRL Computer Networking and Information Technology (CNIT) Division arranged Two days training session on Gateway Level Perimeter Network Security device/appliance of PRL for CNIT staff members on 18 th & 19 th July 2023 at Navrangpura Campus. The main objective of the programme was to familiarize all CNIT staff members with the newly installed Gateway Level Perimeter Network Security architecture, management and monitoring aspects for day-to-day activities related to project. Considering CNIT teams over all work responsibility, the training programme was arranged in two half-day morning sessions. The newly implemented BGP (Border Gateway Protocol) architecture at perimeter level, features of open-source pfSense firewall appliance and various basic concepts/ terminologies of firewall security architecture and rules implemented at PRL were covered during the training program. Moreover Intrusion Detection System (IDS) / Intrusion Prevention System (IPS) based features implemented through 3 rd party commercial services like ET Pro rules & Snort rules were discussed & explained in detail, these rules database provides defense against Emerging Threats During the training recently implemented Site-to-Site Virtual Private Network (VPN) Tunnel between Navrangpura Campus to USO campus and Mt. Abu Campus using different set of pfSense hardware firewalls was also explained and discussed. The training program employed a combination of talks, live demonstrations, physical level cables/ports identification and interactive discussions to ensure active learning and engagement. All CNIT staff members have actively participated in the training and appreciated the training program. CNIT team thank Director, PRL, Registrar, PRL, Dean, PRL, Chair, Computer Committee and IT Security Committee for their continuous support & motivation.

Courses/Training attended by PRL's Scientific and Technical Staff

1. Dr. Santosh Vadawale, Discussion meeting on Lunar Gravitational Wave Meet, International Centre for Theoretical Sciences (ICTS), Bengaluru, 17-20 April, 2023.
2. Mr. Jigar A Raval, 2 Days Certificate Workshop on Cyber Laws, National Law University, New Delhi, 12-13 May, 2023.
3. Dr. Mudit Kumar Srivastava, The International Conference on "Spacecraft Mission Operation-2023" jointly organized by ISRO, ASI and IAA, Taj Vivanta, Yeshwantpur, Bengaluru, 8-9 June, 2023.
4. Mr. Ashish Kumar, ISRO Induction Training Programme (IITP-34), SAC, Ahmedabad, SDSC-SHAR visit, 8-13 August, 2023.
5. Dr. S. Vijayan, Discussion meeting on Lunar Gravitational Wave Meet, International Centre for Theoretical Sciences (ICTS), Bengaluru, 17-20 April, 2023.
6. J. P. Pabari, The International Conference on "Spacecraft Mission Operation-2023" jointly organized by ISRO, ASI and IAA, Taj Vivanta, Yeshwantpur, Bengaluru, 8-9 June, 2023.
7. Prashant Kumar, The International Conference on "Spacecraft Mission Operation-2023" jointly organized by ISRO, ASI and IAA, Taj Vivanta, Yeshwantpur, Bengaluru, 8-9 June, 2023.
8. Manan Shah, The International Conference on "Spacecraft Mission Operation-2023" jointly organized by ISRO, ASI and IAA, Taj Vivanta, Yeshwantpur, Bengaluru, 8-9 June, 2023.
9. Arpit Rasiklal Patel, The International Conference on "Spacecraft Mission Operation-2023" jointly organized by ISRO, ASI and IAA, Taj Vivanta, Yeshwantpur, Bengaluru, 8-9 June, 2023.
10. Chithra Raghavan, ISRO Induction Training Programme (IITP-34), SAC, Ahmedabad, 03 July to 07 August, 2023.
11. Prachi Vinod Prajapati, ISRO Induction Training Programme (IITP-34), SAC, Ahmedabad, 03 July to 07 August, 2023.
12. B S Bharath Saiguhan, ISRO Induction Training Programme (IITP-34), SAC, Ahmedabad, 03 July to 07 August, 2023.
13. Shivansh Verma, ISRO Induction Training Programme (IITP-34), SAC, Ahmedabad, 03 July to 07 August, 2023.
14. Jacob Sebastian, ISRO Induction Training Programme (IITP-34), SAC, Ahmedabad, 03 July to 07 August, 2023.
15. Jayanth R, ISRO Induction Training Programme (IITP-34), SAC, Ahmedabad, 03 July to 07 August, 2023.
16. Shreya Mishra, ISRO Induction Training Programme (IITP-34), SAC, Ahmedabad, 03 July to 07 August, 2023.
17. Kolencheri Jithendran Nikitha, ISRO Induction Training Programme (IITP-34), SAC, Ahmedabad, 03 July to 07 August, 2023.
18. Shivanshi Gupta, ISRO Induction Training Programme (IITP-34), SAC, Ahmedabad, 03 July to 07 August, 2023.
19. Soumya Kohli, ISRO Induction Training Programme (IITP-34), SAC, Ahmedabad, 03 July to 07 August, 2023.
20. Rutuj Gharate, ISRO Induction Training Programme (IITP-34), SAC, Ahmedabad, 03 July to 07 August, 2023.
21. Aniket, ISRO Induction Training Programme (IITP-34), SAC, Ahmedabad, 03 July to 07 August, 2023.
22. Abhishek Kumar, ISRO Induction Training Programme (IITP-34), SAC, Ahmedabad, 03 July to 07 August, 2023.
23. Ashish Kumar, ISRO Induction Training Programme (IITP-34), SDSC-SHAR visit, 8-13 August, 2023.

24. Chithra Raghavan, ISRO Induction Training Programme (IITP-34), SDSC-SHAR visit, 8-13 August, 2023.
25. Prachi Vinod Prajapati, ISRO Induction Training Programme (IITP-34), SDSC-SHAR visit, 8-13 August, 2023.
26. B S Bharath Saiguhan, ISRO Induction Training Programme (IITP-34), SDSC-SHAR visit, 8-13 August, 2023.
27. Shivansh Verma, ISRO Induction Training Programme (IITP-34), SDSC-SHAR visit, 8-13 August, 2023.
28. Jacob Sebastian, ISRO Induction Training Programme (IITP-34), SDSC-SHAR visit, 8-13 August, 2023.
29. Jayanth R, ISRO Induction Training Programme (IITP-34), SDSC-SHAR visit, 8-13 August, 2023.
30. Shreya Mishra, ISRO Induction Training Programme (IITP-34), SDSC-SHAR visit, 8-13 August, 2023.
31. Kolencheri Jithendran Nikitha, ISRO Induction Training Programme (IITP-34), SDSC-SHAR visit, 8-13 August, 2023.
32. Soumya Kohli, ISRO Induction Training Programme (IITP-34), SDSC-SHAR visit, 8-13 August, 2023.
33. Rutuj Gharate, ISRO Induction Training Programme (IITP-34), SDSC-SHAR visit, 8-13 August, 2023.
34. Aniket, ISRO Induction Training Programme (IITP-34), SDSC-SHAR visit, 8-13 August, 2023.
35. Abhishek Kumar, ISRO Induction Training Programme (IITP-34), SDSC-SHAR visit, 8-13 August, 2023.
36. Shital Hitesh Patel, Medical Conference "ACDS-2023", The Ananta, Udaipur, Rajasthan, 7-9 July, 2023.
37. Pragya Pandey ", "International Conference on Women in Physics)ICWIP)- 2023 through Online Mode, Online, 9-14 July, 2023.
38. Neeraj Rastogi, State Level Awareness Workshop on e-Governance Standards & Guidelines, Fairfield by Marriott, Ahmedabad, 10-11 July, 2023.
39. Tejas Narendra Sarvaiya, State Level Awareness Workshop on e-Governance Standards & Guidelines, Fairfield by Marriott, Ahmedabad, 10-11 July, 2023.
40. Dinesh Mehta, State Level Awareness Workshop on e-Governance Standards & Guidelines, Fairfield by Marriott, Ahmedabad, 10-11 July, 2023.
41. Ram Lakhan Agarwal, State Level Awareness Workshop on e-Governance Standards & Guidelines, Fairfield by Marriott, Ahmedabad, 10-11 July, 2023.
42. Padia Girishkumar, State Level Awareness Workshop on e-Governance Standards & Guidelines, Fairfield by Marriott, Ahmedabad, 10-11 July, 2023.
43. Nurul Alam, Short Term Course on "Open Source Software for Library Management" (OSSLM-2023)", IIT Kharagpur, 24-29 July, 2023.
44. Partha Konar, One Week Training Programme on "Basics of Artificial Intelligence, Machine Learning and Data Sceince", Engineering Staff College of India, Hyderabad, 24-28 July, 2023.
45. Akash Ganguly, One Week Training Programme on "Basics of Artificial Intelligence, Machine Learning and Data Sceince", Engineering Staff College of India, Hyderabad, 24-28 July, 2023.
46. Amzad Hussain Laskar, 5-day Training Programme on "Science and Technology for Disaster Risk Reduction" for Scientists & Technologists working in Government Sector, LBSNAA, Mussoorie, 24-28 July, 2023.
47. Shubhra Sharma, 5-day Training Programme on "Science and Technology for Disaster Risk Reduction" for Scientists & Technologists working in Government Sector, LBSNAA, Mussoorie, 24-28 July, 2023.
48. Harish Gadhavi, ISRO Structured Training Programme (STP), NESAC, Meghalaya, 7-8 August, 2023.
49. Dwijesh Ray, ISRO Structured Training Programme (STP), NESAC, Meghalaya, 7-8 August, 2023.
50. S. Ramachandran, Workshop on "Indigenous capacity development including research on low global warming (GWP) chemicals to be used as alternatives to Hydrofluorocarbons (HFCs) during implementation of the Kigali Amendment to the Montreal Protocol", The Theatre (Kadamba/Rudraksha/Amaltas) Convention Centre, India Habitat Centre, Lodhi Road, New Delhi, 04 August 2023.
51. Kaila Bipinkumar, The Geometric Dimensions & Tolerances Training Programme, National Skill Training Institute (NSTI), Chennai, 4-8 September, 2023.
52. Suthar Pramodkumar, The Geometric Dimensions & Tolerances Training Programme, National Skill Training Institute (NSTI), Chennai, 4-8 Spetember, 2023.
53. Vishnubhai R Patel, Application of Auto CAD drafting- Basic training, National Skill Training Institute (NSTI), Chenai, 11-15 September, 2023.
54. S. Vijayan, Workshop on "Emerging Technologies", SAC, Ahmedabad, 12-13 September, 2023.
55. R. R. Mahajan, Workshop on "Emerging Technologies", SAC, Ahmedabad, 12-13 September, 2023.
56. A. K. Sudheer, Workshop on "Emerging Technologies", SAC, Ahmedabad, 12-13 September, 2023.
57. Dr. Prashant Kumar, Workshop on "Emerging Technologies", SAC, Ahmedabad, 12-13 September, 2023.
58. Rishitosh Kumar Sinha, Workshop on "Emerging Technologies", SAC, Ahmedabad, 12-13 September, 2023.
59. Deekshya Roy Sarkar, Workshop on "Emerging Technologies", SAC, Ahmedabad, 12-13 September, 2023.
60. Chithra Raghavan, Workshop on "Emerging Technologies", SAC, Ahmedabad, 12-13 September, 2023.
61. Rishikesh Sharma, Workshop on "Emerging Technologies", SAC, Ahmedabad, 12-13 September, 2023.
62. Vivek Kumar Mishra, "Hindi Diwas and Third All India Official Language Conference", Shree Shiv Chhatrapati Sports Complex, Balewadi, Pune, 14-15 September, 2023.
63. Bireddy Ramya, "Hindi Diwas and Third All India Official Language Conference", Shree Shiv Chhatrapati Sports Complex, Balewadi, Pune, 14-15 September, 2023.
64. Tejas N Sarvaiya, "Hindi Diwas and Third All India Official Language Conference", Shree Shiv Chhatrapati Sports Complex, Balewadi, Pune, 14-15 September, 2023.
65. Shiv Kumar Goyal, ISRO Structured Training Programme (STP), PRL, Ahmedabad, 25-29 September, 2023.
66. Amitava Guharay, ISRO Structured Training Programme (STP), PRL, Ahmedabad, 25-29 September, 2023.

67. Sanjay Kumar Mishra, ISRO Structured Training Programme (STP), PRL, Ahmedabad, 25-29 September, 2023.
68. Nirbhay Upadhyay, ISRO Structured Training Programme (STP), PRL, Ahmedabad, 25-29 September, 2023.
69. Prashant Kumar, ISRO Structured Training Programme (STP), PRL, Ahmedabad, 25-29 September, 2023.
70. Bireddy Ramya, ISRO Structured Training Programme (STP), PRL, Ahmedabad, 25-29 September, 2023.
71. Chithra Raghavan, ISRO Structured Training Programme (STP), PRL, Ahmedabad, 25-29 September, 2023.
72. R P Singh, ASSOCHAM 3rd India Quantum Technology Conclave 2023, Hotel Taj Mahal, Mansingh Road, New Delhi, 05 October, 2023.
73. Goutam Kumar Samanta, ASSOCHAM 3rd India Quantum Technology Conclave 2023, Hotel Taj Mahal, Mansingh Road, New Delhi, 05 October, 2023.
74. Manash Ranjan Samal, Structured Training Programme (STP)-2023 on the theme "Indian Space Policy", ISRO Devanahalli Guest House, 30 October, 2023 - 03 November.
75. Jitendra Kumar Panchal, Training Programme on "Electrical Maintenance and Safety", National Skill Training Institute (NSTI), Bengaluru, 06-10 November, 2023.
76. Shaileshgiri I. Goswami, Training Programme on "Electrical Maintenance and Safety", National Skill Training Institute (NSTI), Bengaluru, 06-10 November, 2023.
77. Shital H. Patel, To attend 51st Annual conference of the Research Society for Study of Diabetes in India (RSSDI- 2023, Jio World Convention Centre, Mumbai, 16-19 November, 2023.
78. Keshav Prasad, Trainig Programme on "Project Management", National Skill Training Institute (NSTI), Chennai, 20-24 November, 2023.
79. Padia Girishkumar D, ISRO/DOS Training Programme on "Log Analysis Techniques and Management", Online, 22 November, 2023.
80. Prashant Jangid, ISRO/DOS Training Programme on "Log Analysis Techniques and Management", Online, 22 November, 2023.
81. Shiv Kumar Goyal, Structured Training Programme on "Orbital Platforms- Design, Realization and Servicing for long term sustainability", ISRO Guest House, Devanahalli, Bengaluru, 04-08 December, 2023.
82. Shital Hitesh Patel, Joint International Conference-2024, Club 07, Ahmedabad, 05-07 January, 2024.
83. Ravindra Pratap Singh, Structured Training Programme on "Evolution and advancements in sensors and optical system for Indian Space Programme", ISRO Guest House, Devanahalli, Bengaluru, 08-12 January, 2024.
84. Chandan Kumar, Structured Training Programme on "Evolution and advancements in sensors and optical system for Indian Space Programme", ISRO Guest House, Devanahalli, Bengaluru, 08-12 January, 2024.
85. Rajeshkumar G. Kaila, Training on "Mechatronics", National Skill Training Institute (NSTI), Bengaluru, 05-09 February, 2024.
86. Adalja Hiteshkumar Lavjibhai, Structured Training Programme on "High Energy Materials & Systems Design", VSSC, Thiruvanthapuram, 12-16 February, 2024.
87. Vishal Joshi, Structured Training Programme on "Space Situational Awareness & Debris Management, ISTRAC, Bengaluru, 19-23 February, 2024.
88. Shital Hitesh Patel, 79th Annual Conference of "The Association of Physician of India (APICON-2024), Bharat Mandapam (IECC), New Delhi, 22-25 February, 2024.
89. Bijaya Kumar Sahoo, Online Training Programme on "Administrative Vigilance- Role of IO/PO", ISTM, New Delhi, 04-08 March, 2024.
90. Sachindranatha Naik, Online Training Programme on "Administrative Vigilance- Role of IO/PO", ISTM, New Delhi, 04-08 March, 2024.
91. Neeraj Rastogi, Online Training Programme on "Administrative Vigilance- Role of IO/PO", ISTM, New Delhi, 04-08 March, 2024.
92. Saba Abbasi, Induction training programme for newly recruited Assistants/ UDC/ JPA/ Hindi Typists in DOS/ ISRO units, URSC, Bengaluru, 28 August - 08 September, 2023.
93. Harshaben Parmar, RTI Workshop, SAC, Ahmedabad, 21-22 December, 2023.

Courses/Training attended by PRL's Administrative Staff courses

1. Deepak Kumar Prasad, Induction training programme for newly recruited Assistants/ UDC/ JPA/ Hindi Typists in DOS/ ISRO units, NRSC, Hyderabad, 12-23 June, 2023.
2. Suraj Kumar, Induction training programme for newly recruited Assistants/ UDC/ JPA/ Hindi Typists in DOS/ ISRO units, NRSC, Hyderabad, 12-23 June, 2023.
3. Saurabh Suman, Induction training programme for newly recruited Assistants/ UDC/ JPA/ Hindi Typists in DOS/ ISRO units, NRSC, Hyderabad, 12-23 June, 2023.
4. Richa Prashant Kumar, "International Conference on Women in Physics (ICWIP)- 2023 in Online Mode, Online, 9-14 July, 2023.
5. Mantu Meher, Induction training programme for newly recruited Assistants/ UDC/ JPA/ Hindi Typists in DOS/ ISRO units, LPSC, Valimala, Trivandrum, 10-21 July, 2023.
6. Shreya Pandey, Induction training programme for newly recruited Assistants/ UDC/ JPA/ Hindi Typists in DOS/ ISRO units, LPSC, Valimala, Trivandrum, 10-21 July, 2023.
7. Shashi Kant, Induction training programme for newly recruited Assistants/ UDC/ JPA/ Hindi Typists in DOS/ ISRO units, LPSC, Valimala, Trivandrum, 10-21 July, 2023.
8. Rashmi Ranjan, State Level Awareness Workshop on e-Governance Standards & Guidelines, "C-DAC and STQC Directorate under the aegis of MEITY Venue: Fairfield by Marriott, Ahmedabad", 10-11 July, 2023.
9. Debi Prasad Pradhan, State Level Awareness Workshop on e-Governance Standards & Guidelines, "C-DAC and STQC Directorate under the aegis of MEITY Venue: Fairfield by Marriott, Ahmedabad", 10-11 July, 2023.
10. Ishita P. Shah, State Level Awareness Workshop on e-Governance Standards & Guidelines, "C-DAC and STQC Directorate under the aegis of MEITY Venue: Fairfield by Marriott, Ahmedabad", 10-11 July, 2023.

11. Pradeep Singh Chauhan, MDP on Public Procurement (Advance), AJNIFM, Faridabad, 24-28 July, 2023.
12. Pradeep Singh Chauhan, Training Programme on ”Public Procurement Principles”, Administrative Staff College of India, Hyderabad, 7-11 August, 2023.
13. Kanhav Mulasi, Induction training programme for newly recruited Assistants/ UDC/ JPA/ Hindi Typists in DOS/ ISRO units, URSC, Bengaluru, 28 August - 08 September, 2023.
14. Jyoti Limbat, Induction training programme for newly recruited Assistants/ UDC/ JPA/ Hindi Typists in DOS/ ISRO units, URSC, Bengaluru, 28 August - 08 September, 2023.
15. Saba Abbasi, Induction training programme for newly recruited Assistants/ UDC/ JPA/ Hindi Typists in DOS/ ISRO units, URSC, Bengaluru, 28 August - 08 September, 2023.
16. Sandeep Bhagwandas Manglani, Induction training programme for newly recruited Assistants/ UDC/ JPA/ Hindi Typists in DOS/ ISRO units, URSC, Bengaluru, 28 August - 08 September, 2023.
17. Rumkee Dutta, To attend ”Hindi Diwas and Third All India Official Language Conference”, Shree Shiv Chhatrapati Sports Complex, Balewadi, Pune, 14-15 September, 2023.
18. Priti K Poddar, To attend ”Hindi Diwas and Third All India Official Language Conference”, Shree Shiv Chhatrapati Sports Complex, Balewadi, Pune, 14-15 September, 2023.
19. Hemal D Shah, Training Programme on ”Public Procurement Principles”, Administrative Staff College of India, Hyderabad, 27 November- 01 December, 2023.
20. Kuntar Bhagirathkumar K, RTI Workshop, SAC, Ahmedabad, 21-22 December, 2023.
21. Kartik Patel, Inter-Centre Hindi Technical Seminar, ISRO, HQ, Bengaluru, 21-22 December, 2023.
22. Amee Kartikumar Patel, Inter-Centre Hindi Technical Seminar, ISRO, HQ, Bengaluru, 21-22 December, 2023.
23. Rumkee Dutta, 5-day Refresher Training Programme for DOS/ISRO Officers working in Administration, ISRO HQ, Bengaluru, 16-20 January, 2024.
24. Kuntar Bhagirathkumar K., 5-day Refresher Training Programme for DOS/ISRO Officers working in Administration, ISRO HQ, Bengaluru, 16-20 January, 2024.
25. Abhishek, 5-day Refresher Training Programme for DOS/ISRO Officers working in Administration, ISRO HQ, Bengaluru, 16-20 January, 2024.
26. Kartik Patel, 5-day Refresher Training Programme for DOS/ISRO Officers working in Administration, LPSC, Valimala, Thiruvananthapuram, 22-27 January, 2024.
27. Rumkee Dutta, 03 days Official Language Orientation Program, IPRC, Mahendragiri, 23-25 January, 2024.
28. Ishita Pravinchandra Shah, 5-day Refresher Training Programme for Accounts Officers working in DOS/ISRO, VSSC, Thiruvanthipuram, 05-09 February, 2024.
29. Krishna Dhanunjayachari, 5-day Refresher Training Programme for Accounts Officers working in DOS/ISRO, VSSC, Thiruvanthipuram, 05-09 February, 2024.
30. Akhila P N, 5-day Refresher Training Programme for Accounts Officers working in DOS/ISRO, VSSC, Thiruvanthipuram, 05-09 February, 2024.

Official Language promotion at PRL

Rajbhasha Activities held during April 2023-March 2024

The Physical Research Laboratory (PRL), being one of the premier Research Institute, is maintaining the outreach to different strata of work force and common people. This breeze of enthusiasm is maintained in the innovative ways of promotion Official Language activities too. Some of the noteworth acitivites held throughout the year are as follows:

1. Physical Research Laboratory, Ahmedabad has been awarded the First prize for the second consecutive time for the best implementation of the Official Language Policy of the Government of India during 2022-23 at the Town Official Language implementation level. The Prize was awarded by TOLIC in a meeting held on 27.07.2023.
2. In order to review the implementation of the Official Language Policy, compliance and achieving the targets set by DOL, Official Language Implementation Committees are formed. The Committee meetings are conducted every quarter under the Chairmanship of Head of Office. The main objective of the formation of these committees is to promote progressive use of Hindi in official work and to overcome the difficulties in its path. The quarterly Meetings were held on 27 June 2023, 28 Sep 2023, 28 Dec 2023, 13 March 2024.
3. In order to provide training and support to undertake Hindi work in computer to provide information about the Incentive schemes related to Hindi work, to ensure strict compliance of Official Language Rules, and to impart other trainings in Official Language, Workshops are conducted in each quarter. The Hindi Workshops were held on 16 June 2023, 17 July 2023, 28 Nov. 2023 & 19 March 2024 for new entrants in PRL, Senior Project Assistants and Officers, Assistants and Senior Assistants & Level 11 PRL Staff Members respectively.
4. Inspection of Physical Research Laboratory, Ahmedabad by the Second Sub-Committee of the Parliamentary Official Language Committee at Rajkot on 10 July 2023.
5. Departmental Annual Hindi Inspection of PRL Main Campus was held on 28 Dec. 2023.
6. Departmental Annual Hindi Inspection of PRL USO Campus was held on 12 Dec. 2023.
7. Departmental Annual Hindi Inspection of PRL IRO Campus was held on 12 Dec. 2023.

Hindi Technical Seminar

Hindi Technical Seminar on Scientific and technological innovations for sustainable development was organized by PRL on 16 August 2023. In this Seminar, Udaipur Solar Observatory, Mt. Abu Infrared Observatory and Space Applications Centre also participated along with Thaltej & PRL Main campus.

Hindi Diwas and Third All India Official Language Conference in Pune was held on 14 and 15 September 2023. PRL, members were nominated for participation in the Program. PRL, Ahmedabad celebrated Hindi Maah 2023 from 19th September to 14th October 2023.

Hindi Month 2023 inauguration in PRL was held on 19 Sep. 2023.
a. Kavita Path competition and Kavi Sammelan was held on 19 Sep. 2023.

b. Aashubhashan competition and Vaad-vivaad competition was held on 26 Sep. 2023.

c. Kahani Lekhan competition (for class 7-10 students) was held on 29 Sep. 2023.

d. Chitra Varnan competition was held on 03 Oct. 2023.

e. Our Work competition (Hamara Kary) was held on 05 Oct. 2023.

f. Gayan program was held on 07 Oct. 2023.

g. Word Quiz competition was held on 10 Oct. 2023.

h. 08 October, 2022: Hindi Gayan program was held.

i. Laghunatika competition was held on 14 Oct. 2023.

j. On-stage live Hindi drama was held on 14 Oct. 2023.

Organization of Gujarat State Level Hindi Technical Seminar on November 24, 2023

Gujarat State Level Hindi Technical Seminar- 2023 was organized by Physical Research Laboratory, Ahmedabad for the promotion of official language Hindi on 24 November 2023. Its main theme was: Innovative Ideas and Initiatives. The chief guest of this program was Shri Yashwant U. Chavan (Indian Revenue Service), Principal Chief Commissioner of Income Tax, Ahmedabad. About 35 articles were received from various offices of the State, out of which 17 articles were included in the seminar as follows:

1. Ranjan Parnami , Space Applications Centre : “Role of space startups and indigenization in ISRO projects”
2. Neha Gour, Space Applications Centre : Help System for

Women Victims through RFID (Radio Frequency Identification) Tags Technology (Krishna Help Me)

3. Yogesh Ghotekar , Space Applications Centre : Use of nano materials in space missions
4. J.P. Singh , Space Applications Centre : Software Defined Satellites: Concept, Opportunities and Challenges
5. Shubham Gupta, National Water Development Agency: Smart Water Meter App
6. Rajendra Gaikwad , Space Applications Centre : Vocabulary Conversation Application
7. Deepak Agarwal , Space Applications Centre : Embedded Passive Technology- EPT
8. Girish Padia , Physical Research Laboratory : IT Asset Inventory Management
9. Parshant Jangir, Physical Research Laboratory : Cyber-security and individual
10. Jitender Kumar, Space Applications Centre : Optical Domain Compression Based Camera: Design and Development
11. Dinesh Agarwal, Space Applications Centre : Printed Electronics: Innovation in Space Exploration
12. Amarnath , Space Applications Centre : Important role of modern micro connectors and flexi rigid printed circuit board in the development of front-end electronics of cartographic camera.
13. Arpan Bajpayi , Central Bank of India: Water conservation - new efforts
14. Shubhra Sharma, Physical Research Laboratory : Understanding of floods, forest fires, climate change and human interference in the Himalayas over geological chronology.
15. Richa Prashant Kumar, Physical Research Laboratory : Initiatives and Innovations in relation to Institutional Canteens: A Case Study of PRL Canteen
16. Prashant Gupta , Space Applications Centre : Virtual presence of humans in space and planets
17. Yogesh Parth , Space Applications Centre : Innovative ideas and initiatives in space exploration

Other activities for the promotion of Official Language held at PRL

Smt. Amee Kartik Patel from PRL participated in Bank of Baroda Hindi Technical Seminar on Importance of ESG in corporate sector Present and Future topic on 07 Aug 2024.

According to the instructions issued by Department of Space, Children of staff members of PRL, securing highest marks in hindi subject in X and XII std. 2023 exams conducted by CBSE, ICSE and State Boards were be awarded.

Inter-Centre Hindi Technical Seminar, ISRO HQ, Bengaluru was held on 21-22 Dec. 2023.

(a) Smt. Amee Kartik Patel presented on Indias initiative to become carbon neutral and its significance.

(b) Shri Kartik Patel presented on Causes and remedies of various environmental Pollution.

(c) Smt. Sonam Jitarwal presented on Development of Venus Orbiter Dust Experiment (VODEX) for the study of interplanetary dust.

Orientation Program was held on 23-25 Jan. 2024 organized by IPRC, Mahendragiri In this program different aspects of Official Language Implementation were discussed. A session on Kantahastha Translation Tool and usage of MS Word was there. There were sessions by JD (OL) regarding different hardships faced by different Centre/Units in Official Language Implementation and efforts to overcome it. Smt. Rumkee Dutta from PRL participated in this Orientation Program.

On World Hindi Day 10 Jan. 2024, important and interesting facts about Hindi were displayed in the display systems of all the campuses of PRL.

PRL Amrut Rajbhasha Vyakhyan (PARV)

In order to promote use of Rajbhasha in day-to-day work in PRL, a resolution is taken to start a new series of monthly lectures in Official Language Hindi in the year 2023-24. This monthly Hindi lecture series is named ”PRL Amrut Rajbhasha Vyakhyaan (PARV)” PARV lectures by eminent personalities are envisaged to cover wide range of themes encompassing Science and Arts, Engineering & Technology, Literature and Rajbhasha, Corporate Business and Entrepreneurship, Management, Industries and Marketing, Finance and Human Resources. Law and Social Science, Sports and Travelogues. Adventurous missions, Spiritual Philosophy and Traditional Wisdom ”PRL Amrut Rajbhasha Vyakhyaan (PARV)” was inaugurated by Prof. Anil Bhardwaj. In this financial year 10 Vyaakhyans have been delivered.

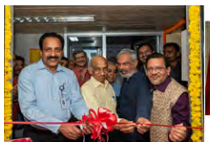
Facilities and Services

Computer Networking and Information Technology (CNIT) Division

The Computer Networking & Information Technology Division (CNIT) is responsible for providing services/facilities like Secure Networking (Internet, Local Area Network, Wifi, SPACENET), High performance Computing, E-mail, Web, DNS, Proxy, VPN, Centralized Printing, DHCP, Video Conference, EGPS, COWAA/COINS, software development and maintenance. Apart from this, CNIT members have actively participated in ISRO/DOS level various Cyber Security Vulnerability Assessment & Penetration Testing (VAPT), Internal Cyber security Audit activities. Following services/facilities are provided by CNIT division during the year 2023-2024.

PARAM VIKRAM-1000 – 01PetaFlops (PF) High Performance Computing (HPC) Cluster Facility:

In June 2023, CNIT division has commissioned the 1PF HPC facility at PRL. The facility has been named as Param Vikram-1000. It is the 14th fastest supercomputer in India [Reference: https://topsc.cdacb.in/filterdetailstry?page=20&slug=July2023]. More details about the facility is available on https://www.prl.res.in/prl-eng/paramvikram1000 Since June 2023, PRL Scientific and Technical fraternity has effectively utilized the facility and published 18 papers where they have acknowledge the Param Vikram-1000 HPC facility in the publication.



Cyber Security Activities at DOS/ISRO:

At DOS/ISRO Level, the CNIT team members have actively contributed either as a team leader or as a member of the following committees

1. Cyber Security Mock Drill (CSMD)
2. Vulnerability Assessment & Penetration Testing (VAPT)
3. Root Cause Analysis (RCA)
4. Inter Center Cyber Security Audit of IT Infrastructure

Cyber Security Activities at PRL

1. CNIT team has established secure network connectivity with ISSDC, ISTRAC, Bengaluru to PRLs payload data server and also harden the security parameters of PRLs Payload data Server.
2. The Internal ISRO/DOS team has successfully completed the cyber security audit of PRLs IT Infrastructure.
3. CNIT team has established secure network connectivity between Main Campus to Gurushikhar, Mount Abu and Udaipur Solar Observatory (USO) campuses, Rajasthan.

File Sharing and Collaborative Document Editing Service - PRLNabh:

CNIT has setup file sharing facility and collaborative document editing service named “PRLNabh” using open source Nextcloud software. The system has been secured using Multi-Factor Authentication (TOTP), Web Application Firewall, Denial of Service (DoS) protection, Login-Password brute force protection etc.

Software Development and Management:

1. **ASPEX Web Site:** CNIT members have designed and developed a secure and responsive web portal for displaying the information, activities, and publications related to the Aditya Solar Wind Particle Experiment (ASPEX) payload, one of the payloads of PRL for the Aditya-L1 mission. In this version all the contents are static.
2. **Automation through Web Applications for Web Content Management:** CNIT team members have recently developed as well as further improve the various web application to automate the information updation work flow of PRL website content like “Whats New”, “Recent Publications”, “PRL In News”, “RTI”, “Tenders”, “Recruitment, PARV”, “PKAV”, “Scientific Divisions Web Pages”, “Colloquiums/Seminars”, “Hindi Thought, Today’s Hindi Word”, “Hindi Cell”, and many more. The application automatically send an email to Hindi Section to update modified English contents in Hindi.
3. **NSD and VIKAS Web and OMR Applications:** The CNIT team has developed application for registration of students participating in NSD and VIKSA scholarship programs. Over 5700 students enrolled for NSD 2024 and VIKAS 2024.

   An application for evaluating of OMR sheets of students who participated in screening exam of NSD and VIKAS 2024 was also developed by CNIT. A total of 5725 students from 3219 schools registered for the OMR-based examinations.The examinations proceeded smoothly and successfully.
4. **SMS Gateway:** The service has been integrated with web applications like Recruitment.

CNIT Nukkad - Chai Pe Byte

To share the experiences & knowledge in the different IT verticals like Web, Email, HPC, Cyber Security, Cloud Technology and to strengthen the overall bonding between CNIT Division and PRL colleagues, CNIT division has started new initiative “CNIT Nukkad

-Chai Pe Byte". As a part of this initiative, CNIT has organized the following sessions on different IT verticals:

1. High Performance Computing Param Vikram-1000 (August 02, 2023 and January 30, 2024)
2. Web Application Explore PRL Website (August 31, 2023)
3. File Sharing and Collaborative Document Editing PRLNabh (February 28, 2024)

Hindi Language Promotion Activities

1. Laghunatika/Skit on the theme of Cyber safety and security to spread the awareness regarding frauds happening in society through USB media and threats associated with untrusted USB media as part of Laghunatika Pratiyogita, Hindi Maah programme 2023-24.
2. Papers presented in Hindi Technical Seminar 2023: 1) Virtualisation - Virtualization - a cost-effective and eco-friendly key enabler of digital transformation, Quantum Technology 2) Quantum computing and technological innovation from scientific innovation to sustainable communication.
3. Papers presented in Gujarat State Level Hindi Technical Seminar 2023: 1) Inventory Management of IT Assets 2) Cyber Security and Individuals.

Library & Information Services

Library and Information Services plays an important role in catering to the information needs of the PRL researchers and staff members. These information services are being provided in all the campuses of PRL. A few important ones are - documents (books, journals, CDs) lending services, Online Access (internet and through remote access) to Institutional Repository, E-journals, Theses, E-books, Archives, Technical Reports, etc. The library also provides the Inter Library Loan facility, Research Support Services like Similarity Checks, Grammar Check, Research Impact Measurement Services, Reprography, Information display through the Digital Notice Boards, and Book procurement for project grants. The updates and additions to the library during the year 2023-24 are mentioned below:

New books added	579
New E-books added	1745
Journals subscribed	231
Circulation Service	3552
Inter Library Loan Service	96
Reprographic Service	17840
Similarity Check Service	106
Physical validation of Bound Volumes 1954-2015 (Thaltej & USO)	5938

Figure 1: Statistical Overview for 2023-2024

Library Online Resources: PRL Library has access to full-text databases like GSA Archive, PROLA, Science Archive, ProQuest Dissertation and Theses (PQDT). The Library also has access to Nature.com and Springer Journals, Elsevier Journals, and Wiley Journals in addition to SPIE and IEEE Digital Library through Antariksh Gyaan which is an ISRO Library Consortium. SCOPUS citation database and INSPEC and COMPENDEX databases have been added this year. The librarys new website `https://www.prl.res.in/~library/new_lib/index.html` continues to provide a seamless facility of online resources and information to the patrons of the library.

Digital Notice Board:

The PRL Library uses Digital Notice Boards (DNBs) to disseminate information related to recent activities of the Library and PRL, to the staff members and visitors. These are installed at prominent locations in all four campuses of PRL. Information on recent publications of PRL scientists, new books added to the library collection, announcements of conferences, division seminars, colloquia, public talks, images of events, etc. is being displayed.

Digitization and Archival facility:

PRL Library has been maintaining an Institutional repository using the GSDL software for long. The archive currently consists of research papers, theses, technical notes, and photographs. With the progress in technology and to comply with the Antariksh Gyaan (ISRO) library mandate to build a common institutional repository for all DOS/ISRO libraries using DSpace, PRL Library has initiated the process of setting up a Digitization and Archival facility like procurement of Digital Book Scanner, Server specifications, etc.

The library aims to establish a state-of-the-art archival facility for all intellectual output for PRL. A prototype of Institutional Digital Repository - IDR@PRL (http://172.16.9.181:4000/home) has been developed using DSpace - Open Source Software (OSS). It serves as a single window archiving facility for all the scholarly and creative works (Theses, Technical Reports, Journal Articles, etc.) produced by the institutions faculty, researchers, students, and staff.

Figure 2: Interface of the Prototype Institutional Repository at PRL

Book exhibition:

The Library organized a book exhibition on the 4th and 5th of January 2024. There were around 650 Scientific, General, and Hindi books on

display by four booksellers from Delhi, Bombay, and Ahmedabad. The on-campus exhibition helps the staff to browse through many books in their area of interest which helps build up the library collection. The exhibition attracted active participation from research scholars, staff, and faculty members of PRL, and 370 books were recommended by PRL members for the library.

Figure 3: Book Exhibition

New initiatives by the Library & Information Services:

Design and development of the Union Catalogue of DOS/ISRO libraries has been assigned to the PRL Library. Data from 12 DOS/ISRO centers was collected and a prototype was developed. The demonstration was made to the committee on Oct. 13, 2023. Further, installation of the Union Catalogue Installation on the Space NET (intranet) system and testing

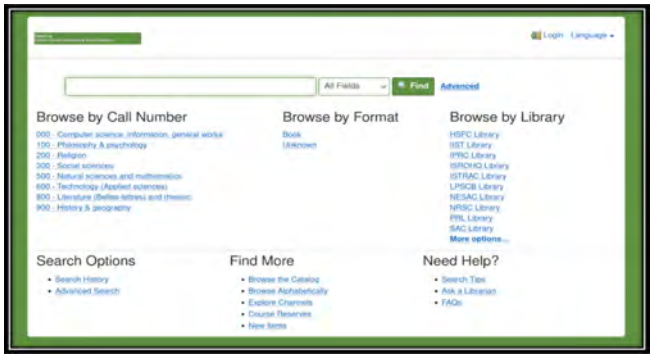


Figure 4: DOS/ISRO Union Catalogue Interface

Research Impact (RI@PRL) :

It can be visualized as a centralized and distributed bibliometric information services system that would help end users-scientists/researchers, policy/decision-makers, etc.This service aims to draw expertise in gathering, managing, and analyzing publications data using statistical methods, and tools (R, VOSViewer). This offers a range of standard and customized analysis services to assist in managing, evaluating, and strengthening scientific research. A 75-year research impact has been analyzed and is made available on the website as a part of the PRL Platinum Jubilee celebration

Bibliometric & Citation Indicator	No.
Time Span	1951 -2022
Document Type	Article & Review
Total Document	6110
Total Citations	123636
Average Citations/article	20.23
H-Index of PRL	122
Annual Growth rate %	8.37

Figure 5: Research Impact Analysis

Hindi Website for Library:

As a part of the initiative towards Rajbhasha promotion, the Hindi version of the existing library website (English) has been developed. This is currently in the process of audit and will soon be available for the users.

Figure 6 : Hindi Website for Library & Information Services

Recognition:

Library and Information Services presented the work and was awarded the 1st prize in the Humara Karya Pratiyogita held during the Hindi Pakhwada Karyakram 2023.

Workshop

PRL's mechanical workshop has been actively working with various groups in PRL. The workshop is engaged in the design optimisation, fabrication, and testing of various mechanical subsystems of several ongoing developmental projects in the laboratory. The PRL workshop facilities in Navrangpura and Thaltej campuses are equipped with several state-of-the-art machines for manufacturing mechanical components. In the financial year 2023-24, the workshop has made notable contributions in developing back-end instruments of Mt. Abu observatory and various subsystems and setups for several scientific payloads for upcoming missions in addition to catering to specific and specialized requirements of many R&D laboratories in PRL. A few highlights are briefed below:

Design and Assembly of the Beamline for XUV-IR Pump-Probe Spectroscopy (Atto Second Beam Line Assembly)

An Attosecond beamline (XUV-IR setup) is being developed in the Femtosecond Laser Lab. This setup consists of a High Harmonic Generation (HHG) vacuum chamber, Cold Target Recoil Ion Momentum Spectrometer (COLTRIMS), Atto Second Pulse Characterization Vacuum Chamber, Focusing Chamber for Atto Second Pulse, and Atto Second Pulse Generation Vacuum Chamber. Fig.:1 Shows a 3-D model for "Assembly of Beamline for XUV-IR Pump-Probe Spectroscopy developed in PRL-Workshop. It was challenging because of the 3-D model of every assembly component, including all vacuum chambers, U-clamps, and Al. Profile Stands, CF Flanges, Gate Valves, CF-100 Cube, Couplers, Connectors, Bellows, Gratings, Gas Cell enclosure, Assembly of Grating Mounting, MCP Detector Assembly, Breadboards, Gate Valves, three & single port cluster flanges, etc., were individually developed and assembled. The "Beam Line Assembly dimensions are 3608 mm L x 1490 mm W x 1522 mm H, and a provision was made for the height alignment of all vacuum chambers.

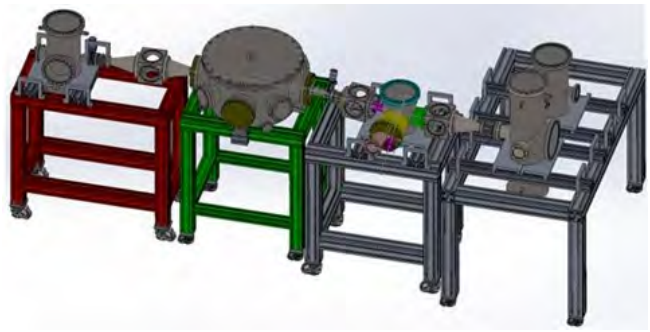


Fig. no.1: Assembly of the Beamline for XUV-IR Pump-Probe Spectroscopy (Atto Second Beam Line Assembly)

Fabrication and Development of Dust Detector Assembly for Studying Interplanetary Dust Particles.

The target tray (size: 276 mm x 254 mm x 50 mm) is the box that houses the electronics, which is covered by an Al., at the bottom. These slots in the target tray allow the handle part of the detector PCB to slide in. The assembly comprises 25 parts, and the PRL workshop fabricated 39 parts, which is shown in Fig.2. This was flown onboard ISROs PSLV Orbital Experimental Module as a pilot study.

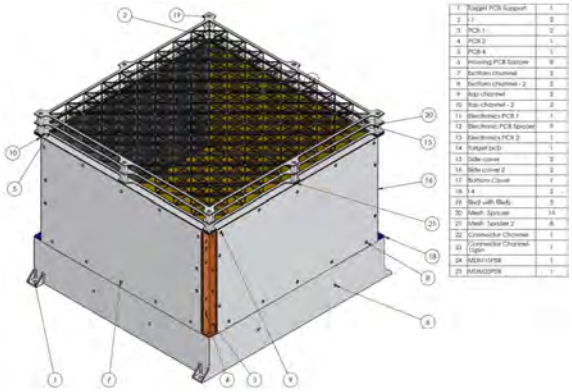


Fig. no.2: Assembly of Target Tray for Dust Detector

Design and Fabrication of Calibration Unit Assembly, Linear Stage Assembly and Enclosure for Low-Resolution Spectrograph (LRS)

LRS has been designed and developed in PRL. It involves precision fabrication for a seamless interface with the 2.5m telescope of PRL. Fig.3, Fig.4 and Fig.5 are shown for Calibration Unit Assembly, Linear (post) Stage Assembly and Low-Resolution Spectrograph, respectively.

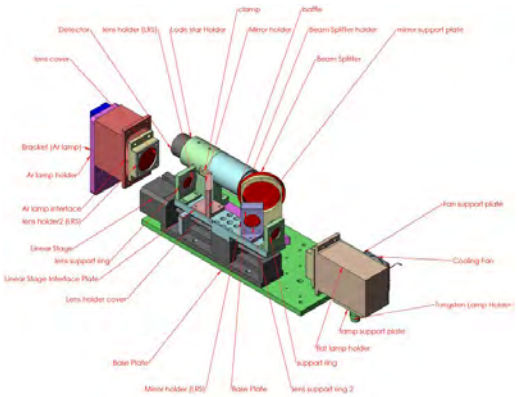


Fig. no.3: Calibration Unit Assembly

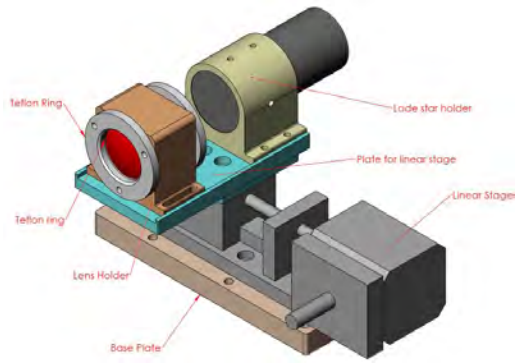


Fig. no.4: Linear(post) Stage Assembly

Fig. no.5: Low-Resolution Spectrograph (LRS)

Design and Fabrication of Gas Cell Enclosure, Assembly of CF160 with CF35 Flange(3 ports.) -Angle 16° View Port and Assembly of CF160 with CF35 Flange-Angle 13°(1 port.), for Attosecond Beam Line Assembly

In the "Gas Cell Geometry, the laser enters the cell and comes out through two small holes across the diameter of the cell. A cubic box of 100 mm x 100 mm x 120 mm size with 80mm holes and KF25 flanges on the sides was developed to reduce the free flow of gas inside the vacuum chamber. The cylindrical gas cells and the cubic enclosure were designed and machined in a PRL-Workshop (fig.6).

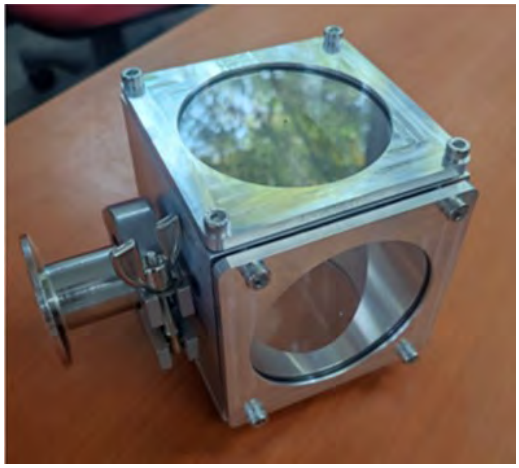


Fig. no. 6: Gas Cell Enclosure

To compensate for the characteristic angle of the grating, a specially customised angular (13°) flange has been made to connect the two chambers. Similarly, a three-port cluster flange has been designed and fabricated to align a laser and two viewports(16°). Fig.7 and Fig.8 are shown for the "Assembly of CF160 with CF35 Flange-1 port" and "Assembly of CF160 with CF35 Flange-3 ports", respectively. For the first time, the PRL-Workshop fabricated a standard CF-160 flange with knife edge & PCD holes and a standard CF-35 rotatable flange with inner and outer parts on a TMC-200 NVU m/c. A special boring tool was developed that is required specifically for machining knife edges.

Fig. no. 7: Assembly of CF160 with CF35 Flange-1 Port

Fig. no. 8: Assembly of CF160 with CF35 Flange-3 Ports

PS4 Langmuir Probe Assembly

The assembly of two-tray (185 mm L x 185 mm W x 96.3 mm H) and three-tray (185 mm x 185 mm x 94.8 mm) was designed & fabricated to house the electrical components of LP for flight in PS4 platform and DISHA mission for measurement of electron density and plasma fluctuations. Machining of all trays was done on VMC-850 m/c. Fig.9 & 10 show "PS4 Langmuir Probe Assemblies" for 2-Tray and 3-Tray packages, respectively

Fig. no. 9: PS4 Langmuir Probe Assembly (2-Tray Package)

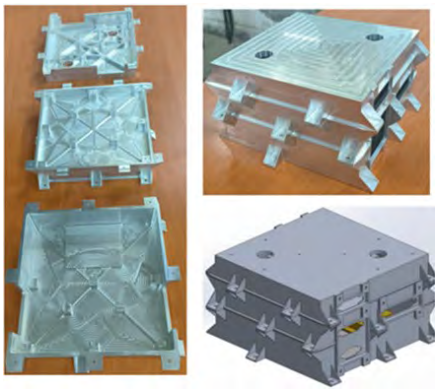


Fig. no. 10: PS4 Langmuir Probe Assembly (3-Tray Package)

Argon Welding Job: Assembly for Residual Gas Analyzer(RGA) and Shield Tube

Argon welding is used for welding stainless steel and other high-quality materials that require precise control over the welding process. In PRL, to develop a Residual Gas Analyser (RGA), a high vacuum stainless steel chamber is required to be fabricated (fig.11).

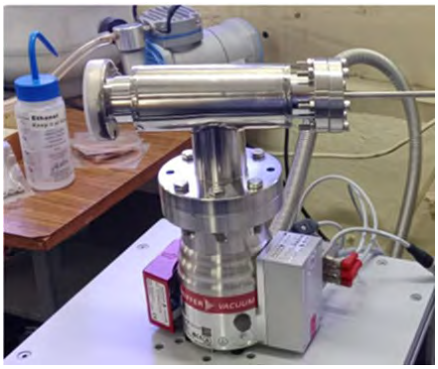


Fig. no. 11: Residual Gas Analyser (RGA)

In this regard, an SS-304 Pipe of OD Ø60mm x ID Ø50 mm x 130 mm and two nos. of SS-304 specialised CF-35 flanges were machined on the TMC-200 nvu m/c., were all argon welded to complete the assembly. For the Shield Tube, a total of three individual parts, e.g. 16CF Flange, 40CF Flange, and an SS-304 tube (OD Ø38mm x ID Ø35 mm x 236 mm L), were welded (argon) to complete the assembly (fig.12).

Fig. no. 12: Shield Tube Assembly

Long Wave Length Array Antenna (LWA) for USO

The Longwave Array Antenna (LWA) was indigenously designed and fabricated in the PRL workshop. The LWA is the wide-band antenna for solar radio observations and radio sky surveys. A total of 12 nos. of parts were fabricated for the assembly of the LWA Antenna. Each antenna element consists of a triangular aluminium frame sloping down from the top and supported from the centre post by non-conductive horizontal fibreglass rod braces, shown in Fig.13. Each element is 1.5 m long x 0.8 m wide.

Fig.: no. 13: Long Wave Array Antenna (LWA) for USO

VeRAD Payload: Detector Stack Assembly

The detector housing was fabricated to support and mount the Micron Semiconductor to make Si PIN detectors. These detectors are dedicated to detecting alpha particles of a few MeVs. Two such detectors are stacked to cover higher energy (10 MeV). The housing consists of a bottom plate to mount the detector using fasteners, a source holder to accommodate the Americium-241 (Am-241) source, and a cover to protect the detector when the source is not being used. This assembly was made for ground-based testing of the detector unit and is planned to be used in the VeRad prototype testing of detector units, which will be integrated with the FEE enclosure. The components were fabricated as per user drawing requirements using a lathe machine and Aluminium alloy material (fig.14).

Fig.: no. 14: VeRAD Detector Stack Assembly

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Honorary Fellows

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90	Jayashree Balan Iyer	Sr. Proj. Assistant	CHSS, BACS, Visitor Mgmnt System, Despatch, Pension Cards, Liasoning Work	ADMGN	B.HSc. (1993)
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93	Jitendra Kumar Panchal	Technician-G	Electrical Maintenance	CMDV	I.T.I (2007)
94	Jyoti Limbat	Sr. Assistant	Registrar's office Administration	ADMRO	M.Sc. (2015)
95	Jyotiranjan S. Ray	Sr. Professor	Isotope Geochemistry	GSDN	PhD (1998)
96	K J Bhavsar	Sci./Eng.-SE	Electrical work	CMDV	B.E. (1995)
97	K.K. Sasikumar	Sr. Admn. Officer	Transport, Estate And Right To Information	ADMGN	M.B.A. (2014)
98	Kaila Bipinkumar	Technician-G	Oparating & Programing On CNC/VMC And EDM Machines, CAD Modeling and CAM Programming	WORSH	TC (2007)
99	Kanhav Mulasi	Sr. Assistant	General Administration	ADMGN	B.Sc. (2017)
100	Kapil Kumar	Sci./Eng.-SE	Astronomical Spectrograph Design, Exoplanetary Science, Mechanical Structural Design, Optimization And Testing, Vacuum Chamber Design, Basic Optical And Optomechanical Design, Basic Astronomical Telescope And Coating Technology	A&A	B.Tech. (2015)
101	Karanam Durga Prasad	Sci./Eng.-SF	Lunar And Planetary Surface Science, Space Instrumentation, Simulation Of Planetary Environments, Numerical Modelling, Planetary Wireless Sensor Networks & Cubesats	PSDN	PhD (2018)
102	Kartik Patel	Admin. Officer	General Administration & Establishment	ADMGN	M.B.A. (2011)
103	Kasarla Prashanth Kumar	Sci./Eng.-SD	Mechanical System Design, Optical And Opto-Mechanical System Design, Dewar And Cryostat Design And Testing, Instrumentation	A&A	B.E. (2017)
104	Kavutarapu Venkatesh	Asst. Professor	Space and Atmospheric Sciences	SPASC	PhD(2013)
105	Keshav Prasad	Technical Assistant	Construction And Maintenance	CMG	B.Tech. (2018)
106	Ketan Patel	Assoicate. Professor	Theoretical High Energy Physics	THEPH	PhD (2012)
107	Keyur D Panchasara	Sr. Proj. Assistant	Cashier & Miscellaneous Payment Work	ADMAC	B.Com (2003)
108	Kinsuk Acharyya	Asso. Professor	Astrochemistry And Astrobiology	PSDN	PhD (2008)
109	Kolencheri Jithendran Nikitha	Sci./Eng.-SC	Astronomy and Astrophysics	A&A	MS (Integrated) (2021)
110	Krishna Dhanunjayachari	Accounts Officer	ACCOUNTS	ADMAC	M.C.A (2011)
111	Kuljeet Kaur Marhas	Professor	Isotope Cosmochemistry, Planetary Scientist	PSDN	PhD (2001)
112	Kuntar Bhagirathkumar K	Administrative Officer	Administrative Work	ADMGN	CC (2018)
113	Kushagra Upadhyay	Sci./Eng.-SD	Antenna Design, RF System And Circuit Design, Solar Radio Instrumentation	USO	B.Tech. (2017)
114	Lad Kevikumar Ashokbhai	Sci./Eng.-SD	Instrumentation, CAD, Finite Element Analysis, Experimental And Computational Fluid Dynamics, Thin Film Coating Systems, Design And Optimization	A&A	B.E. (2017)
115	Lakhansinh G Chavda	Sr. Technician-A	Troubleshooting Of Electronics Breakdown In Scientific Instruments. Soldering/Desoldering work	GSDN	I.T.I (2006)
116	Lakum Yagnikkumar Bhimjibhai	Technician-F	Electronics and IT assistance	CNIT	COMPTR (2011)
117	Lokesh Kumar Dewangan	Asso Professor	Star Formation	A&A	PhD (2011)
118	Lokesh Kumar Sahu	Professor Dy. Head-I, SPASC	Atmospheric Sciences,Trace Gases, Volatile Organic Compounds (VOCs)	SPASC	PhD (2005)
119	Lovjeet Meena	Technical Assistant.	Civil Engineer	USO	D.C.E (2013)
120	M G Yadava	Sr. Professor	Radiocarbon Dating And Paleoclimatology	GSDN	PhD (2003)
121	Maanyash Jain	Scientist/ Engineer-SC	Space And Atmospheric Sciences	SPASC	B.Tech (2023)
122	Mahesh Chand Saini	Technical Assistant.	Astronomy & Astrophysics	AST-AS	Dip. (2017)
123	Mahesh Gaddam	Sr. Sci. Assistant-A	Maintenance And Operation Of Various Instruments Present In The Chemistry Lab	GSDN	M.Sc. (2013)
124	Mahesh Kumar A Raval	Senior Lv Driver-B	Driver	ADMGN	Ninth (1989)
125	Malaidevan P	Sci./Eng.-SD	Electronics (Avionics), Solidwork Software	SPASC	B.Tech. (2015)

Sr. No.	Name	Designation	Specialization	Division	Highest Degree Obtained
126	Manan Shah	Sci./Eng.-SF	Electronics, Design And Development Of Space And Ground Based Scientific Instruments	GSDN	M.Sc. (2016)
127	Manash Ranjan Samal	Associate Professor	Astronomy And Astrophysics: Star Formation, Star Clusters, Interstellar Medium, Young Stellar Objects	A&A	PhD (2011)
128	Manisha D Patel	Senior Nurse-B	Nursing	DISSR	B.Sc. (2009)
129	Manisha Mishra	Sr. Proj. Assistant	Assistance with Purchase and Procurement	ADMPR	M.Sc. (2011)
130	Mantu Meher	Sr. Assistant	Procurement (GeM, Coins, Cash Purchase)	ADMPR	B.Sc. (2015)
131	Md. Nurul Alam	Library Officer -C	Library Automation, Digital Library, Scientometrics, Digitization, Serials Control	LIBSR	PhD (2017)
132	Megha U Bhatt	Assistant Professor	Planetary Remote Sensing, Visible - Infrared Spectroscopy	PSDN	PhD (2012)
133	Mistry Bhaveshkumar V	Technical Assistant	Astronomy & Astrophysics	AST-AS	B.E. (2021)
134	Mitesh B Bhavsar	Sr.Technician-A	Circuit Fabrication And Testing, Soldering/Desoldering Work, Supporting Space Science Instrumentation	SPASC	I.T.I (1998)
135	Mithun Neelakandan Ps	Sci./Eng.-SE	High Energy Astrophysics And Instrumentation	A&A	B.Tech. (2014)
136	Modi Bhavikkumar L	L V Driver-A	Driver	ADMGN	Bachelor of Rural Studies (2008)
137	Mohit Kumar Soni	Sci./Eng.-SD	Avionics Instrumentation (Hardware And Software), Ground Based Insturmentation, Image Processing And Deep Learning	SPASC	B.Tech. (2019)
138	Mudit Kumar Srivastava	Asso. Professor	Observational Astronomy, Studies Of Novae, Symbiotic Stars And Transients, Optical Astronomical Instrumentation, Design And Development Of Optical Imaging And Spectroscopy Instruments	A&A	PhD (2012)
139	N Jain	Sci./Eng.-SE	Design, Development And Coordinate Maintenance Of Electrical Systems at USO	USO	AMIE (2002)
140	N S Rajput	Sr.Tech.-A	Assitance with Telescope operations	A&A	Eight (1985)
141	Nafees Ahmad	Sci./Eng.-SC	Upgradation of 1.2M Infrared Telescope Upgradation, Operations And Maintenance.	A&A	AMIE (2015)
142	Namit Mahajan Dy. Head-I, THEPH	Professor	Theoretical High Energy Physics	THEPH	PhD (2004)
143	Nandini Ravi Rao	Pur. & Stores Officer	Purchase administration	ADMPR	B.Sc. (1991)
144	Nandita Srivastava	Sr. Professor	Solar Physics, Space Weather	USO	PhD (1994)
145	Narendra Ojha	Assistant Professor	Atmospheric Chemistry, Earth System Modeling	SPASC	PhD (2014)
146	Naveen Chauhan	Asso. Professor	Luminescence Dating, Luminescence Physics, Dosimetry	AMOPH	PhD (2013)
147	Navinder Singh	Professor	Theoretical Condensed Matter Physics	THEPH	PhD (2006)
148	Neelam J S S V Prasad	Sci./Eng.-SE	Ground Based Instrumentation, Design And Development Of Hardware And Software For Telescope Back-end Instruments And Control System For Scientific Detectors, Antenna Design And Basic Astronomical Telescope Technology	A&A	B.Tech. (2015)
149	Neeraj Kumar Tiwari	Sci./Eng.-SE	Mechanical And Thermal Design Of Space Instruments And X-Ray Optics Development	A&A	B.Tech. (2015)
150	Neeraj Rastogi Dy. Head-II, GSDN	Asso. Professor	Atmospheric Science: Aerosol Chemistry, Composition, And Characteristics	GSDN	PhD (2005)
151	Neeraj Srivastava	Asso. Professor	Planetary Remote Sensing: Mission Data Analysis For Geology & Laboratory Reflectance Spectroscopy Under Smulated Conditions	PSDN	PhD (2015)
152	Nileshkumar N Dodiya	Sr.Tech.-A	Carpentary Work	CMDV	CC (2000)
153	Nimma Vinitha	Sci./Eng.-SD	Ultrafast Spectroscopy, Laser Physics, Optical Instrumentation	AMOPH	M.Tech. (2019)
154	Nirbhay Kumar Upadhyay	Sci./Eng.-SF	System Engineering Of Space Instrumentation, Aerospace Systems' Mechanical Design, Mechanical Engineering (Spl. In Machine Design)	PSDN	M.Tech. (2008)

Sr. No.	Name	Designation	Specialization	Division	Highest Degree Obtained
155	Nishant Singh	Sci./Eng.-SD	Electronics Engineer, Design And Development Of Space Based Instruments	PSDN	B.E. (2017)
156	Nishtha Anilkumar	Library Officer-F	Library & Information Services, Facilitating Research For Students And Faculty, Research Output Metrics, Scholarly Communication, Copyright Issues, Library History, Project Management	LIBSR	PhD (2012)
157	P Narendra Babu	Sci./Eng.-SD	Electrical works	CMDV	B.Tech. (2013)
158	P S Patwal	Tech. Officer-D	Electrical Engineering	A&A	D.EL.E (1993)
159	Padia Girishkumar D	Sci./Eng.-SD	Database Administration, Web Application Security Auditing, Applicationvirtualization, Linux Server Administration, Shell Scripting	CNIT	M.Tech. (2013)
160	Pankaj Kumar Kushwaha	Sci./Eng.-SD	Electronics, Development Of low current Electronics Circuit For Space-Borne And Ground Based Scientific Instruments, PCB Designing, Checkout And Automation Of Instruments.	SPASC	B.Tech. (2016)
161	Paramita Dutta	Asst. Professor	Theoretical Physics	THEPH	PhD (2015)
162	Parmar Viral M	Sci./Eng.-SF	Electrical Engineering - Capital, Minor And Maintenance Electrical Works	CMDV	B.E. (2002)
163	Partha Konar Dy. Head-II, THEPH	Professor	Theoretical Particle Physics, High Energy Collider, Dark Matter, Neutrino, Supersymmetry, Deep Machine Learning	THEPH	PhD (2005)
164	Patel Anil Shivpujan	Technical Assistant.	Maintenance (Electrical)	CMDV	B.E. (2015)
165	Peddireddy Kalyana Srinivasa R	Sci./Eng.-SD	Mechanical Engineer, Payload Design, Structural And Thermal Analysis Of Payload Structures, Computer Based Numerical Simulations, Experimental Simulations Involving High Vacuum Assemblies	PSDN	B.Tech. (2016)
166	Piyush Sharma	Sci./Eng.-SD	Design Electronics For Space Based Instruments	PSDN	M.Tech. (2017)
167	Pooja Chandravanshi	Sci./Eng.-SD	Electronics And Communication Engineer, Free Space Quantum Communication, Post Processing Of Quantum Key Distribution (QKD) Protocols, Labview Based Data Acquisition And Automation	AMOPH	B.E. (2016)
168	Prachi Vinod Prajapati	Sci./Eng.-SD	Massive Stars-Nonthermal Emission-Particle Acceleration In Astrophysics, Radio Astronomy, NIR-Optical Instrumentation And Observations, Solar System Science	A&A	M.S. (2019)
169	Pradeep Kumar Sharma	Sr. Admn. Officer	General Administration, CISF Matters, Safety and Security, Rajbhasha, Canteen and Catering, Welfare	ADMGN	M.A. (2012)
170	Pradeep Singh Chauhan	Senior Pur. & Stores Officer	International Trade, Contract Law & Management, Government Emarketplace, Service Contracts, Public Procurement	ADMPR	M.Com (2021)
171	Pradip Shivaji Suryawanshi	Sr. Sci. Assistant-A	Ground And Space Based Optical Instrumentation For Ionospheric Studies, Digisonde Data Analysis	SPASC	M.Sc. (2016)
172	Pragya Pandey	Library Officer-C	Information Services & Documentation, Acquisition & Technical Processing, Scientometric Analysis, Library Automation	LIBSR	PhD (2019)
173	Pranav R Adhyaru	Sci./Eng.-SG	Design & Development Of Electronics Hardware And Software For Scientific Applications.	GSDN	B.E. (1991)
174	Prashant Jangid	Sci./Eng.-SD	Web Application Development, Website Development, Web Application Security Auditing, Mathematics, Algorithm, Operating System	CNIT	B.Tech. (2015)
175	Prashant Kumar	Sci./Eng.-SE	Experimental Atomic And Molecular Physics, Laser Plasma Physics, Optical Emission And Mass Spectroscopy, Payload Development	AMOPH	PhD (2020)
176	Pratheeksha Nayak	Sci./Eng.-SD	Radiocarbon Dating Setups, Speleothems, XRD System, Programming, Data Science, Design And Development Of Web Applications For Data Handling, Visualisation And Analysis	GSDN	B.Tech. (2017)
177	Priti K Poddar	Sr. Proj. Assistant	Accounts & Purchase	ADMGN	PGDCA (1993)

Sr. No.	Name	Designation	Specialization	Division	Highest Degree Obtained
178	R A Parmar	Sr. Proj. Attendant	Office attendant	ADMGN	Ninth (1988)
179	R D Deshpande	Registrar & Senior Professor GSDN	Isotope Hydrology, Hydrogeology	GSDN	PhD (2007)
180	R H Kalal	Canteen Boy-C	Canteen Boy -C	ADMGN	Eight (1987)
181	R K Jaroli	Sr. Proj. Assistant	Assistance with office work at USO	USO	B.Com (1987)
182	R P Singh Head, AMOPH	Sr. Professor	Laser Physics, Light Scattering, Singular Optics, Quantum Optics And Quantum Information	AMOPH	PhD (1994)
183	R R Mahajan	Sci./Eng.-SF	Meteorites, Mass Spectrometer, Noble Gas, Nitrogen, Vacuum, Laser, Mars	PSDN	M.Tech. (1997)
184	R R Shah	Sci./Eng.- SG	Instrumentation & Control, Astronomy & Space Appl. Telescope, Satelite Tracking, Pointing, Imaging Space Servilance Simulation And System Development	A&A	M.B.A. (1997)
185	Rahul Pathak	Sci./Eng.-SD	Design And Development Of Electronics For Ground-Based And Space-Borne Instruments. Front-End Processing, Checkout System Design For SCMOS and CMOS, Data Acquisition And Automation	SPASC	B.Tech. (2013)
186	Rahul Sharma	Sci./Eng.-SD	Database Administration (EGPS, COWAA), Networking	CNIT	M.Sc. (2013)
187	Rajesh A Patel	Technician-F	Refridgeration And Air Conditioning Maintenance	CMDV	I.T.I (2014)
188	Rajesh Kumar Kushawaha	Asso Professor	Atomic, Molecular And Optical Physics: Ultrafast Spectroscopy, Collision Physics, Extreme Photonics & Femtosecond/Attosecond Spectroscopy	AMOPH	PhD (2010)
189	Rajeshkumar G Kaila	Sr.Tech.-A	Operating & Programing VMC/ TMC Machine Using Mastercam Software, Design And Fabrication Of User Specific Scientific Jobs, And Working On Conventional Lathe/ Milling Machines	WORSH	CC (2000)
190	Rajiv Ranjan Bharti	Sci./Eng.-SD	Planetary Remote Sensing	PSDN	M.Sc. (2003)
191	Rakeshkumar G Mahar	Sr.Tech.-A	Design And Fabrication Of User Specific Scientific Jobs	CMDV	I.T.I (1998)
192	Ram Lakhan Agrawal	Sci./Eng.-SE	Conventional Lathe And Milling Machines	CMDV	B.Tech. (2013)
193	Ramitendranath Bhattacharyya Dy. Head-II, USO	Professor	Solar Physics, Dynamics Of The Solar Corona, Magnetic Reconnection, Numerical Simulation.	USO	PhD (2006)
194	Rashmi	Sci./Eng.-SC	Design And Development Of Space Based Instruments.	PSDN	B.Tech. (2019)
195	Rashmi Ranjan	Sr. Purchase & Stores Officer	Stores, Purchase, Sale, Administration, Account, Computer Applications, Dgs&D Contract	ADMST	M.A. (2011)
196	Ravi Bhushan	Sr. Professor	Oceanography, Paleoclimate, Ocean Biogeochemistry, AMS Radiocarbon Dating, Cosmogenic Radionuclide Application	GSDN	PhD (2009)
197	Ravindra Pratap Singh	Sci./Eng.-SF	MLT Dynamics, Coupling of Atmospheres, Airglow, Atmospheric Waves, Optical/IR Instrumentation	SPASC	PhD (2018)
198	Richa Prashant Kumar	Senior Catering Manager	Catering, Hospitality And Estate Management	ADMGN	B.Sc. (2009)
199	Rishikesh Sharma	Sr. Sci./Eng.-SC	High-Resolution Spectroscopy And Photometric Data Reduction And Analysis, Characterization Of Exoplanets, Astronomical Instrumentation	A&A	M.Sc. (2017)
200	Rishitosh Kumar Sinha	Sci./Eng.-SE	Planetary Remote Sensing Data Analysis Of Mars And Moon	PSDN	M.Tech. (2011)
201	Rohan Eugene Louis	Asso. Professor	Solar Physics	USO	PhD (2011)
202	Rohit Meena	Sci. Assistant	Atmospheric Science: Aerosol Chemistry, Composition, And Characteristics	GSDN	M.Sc. (2018)
203	Rumkee Dutta	Asst. Director [OL]	Hindi Cell Administration	ADMGN	M.A. (2004)
204	Rutuj Gharate	Sci./Eng.-SC	Electronics And Communication	AMOPH	B.Tech. (2022)
205	S Ramachandran	Sr. Professor	Aerosols, Radiation, and Chemistry-Climate Interactions	SPASC	PhD (1996)
206	S Venkataramani	Sci./Eng.- SG	Atmospheric Science - Trace Gases Related To Ozone In Troposphere	SPASC	M.Sc. (1986)
207	S Vijayan	Assto. Professor	Planetary Remote Sensing	PSDN	PhD (2013)
208	Saba Abbasi	Sr. Assistant (ADHOC)	Purchase services	ADMST	M.B.A. (2015)

Sr. No.	Name	Designation	Specialization	Division	Highest Degree Obtained
209	Sachindranatha Naik Dy. Head-II, A&A	Professor	High Energy Astronomy And Astrophysics	A&A	PhD (2003)
210	Sachin Gavhare	Technical Assistant	Mechanical Engineering(AC)	CMDV	B.E (2014)
211	Samir V Dani Head, Dispensary	Med. Officer-SF	Medical Management Of Communicable And Non-Communicable Diseases, Specialization In Diabetes Management. Chss Management At Dispensary Level.	DISSR	CC (2018)
212	Sandeep B Manglani	Jr. Pers. Assistant	Stenography & Secretarial Work.	ADMDIR	SHAND (2017)
213	Sandeep PS	Purchase & Stores Officer	PURCHASE & STORES	ADMPR	M.B.A.(2006)
214	Sandip Hasmukh Doshi	Tech. Officer-D	Technical Work, Maintanace, Installations And Upgradation Of Hardware And Software. Computer Hardware, Lan Based Networking And Set Up.	A&A	Dip. (1982)
215	Sandipkumar S Galthara	Sr.Tech.-A	Electrical Maintenance Work	CMDV	D.EL.E (2002)
216	Sangeeta Verma	Sr. Sci. Assistant-A	Geosciences, Stable Isotopes	GSDN	M.Phil. (2008)
217	Sanjay Kumar Mishra	Associate Professor	Plasma Physics, Complex (Dusty) Plasmas, Planetary Plasma Atmosphere: Airless Bodies (Like Moon), Theory, Modeling & Implications.	PSDN	PhD (2009)
218	Sanjay S Wairagade Head, CMG	Sci./Eng.-SF	Construction And Maintenance	CMDV	B.E. (1993)
219	Sanjeev Kumar Head, GSDN	Professor	Biogeochemistry, Stable Isotopes, Climate And Environmental Change	GSDN	PhD (2006)
220	Sanjeev Kumar Mishra	Sci./Eng.-SD	Electronics Design, Development And Testing For Space-Based Applications, Numerical Calculation/Simulation, Data Analysis Using Numerical Methods.	PSDN	B.Tech. (2016)
221	Santosh V Vadawale Dy. Head-I, A&A	Sr.Professor	X-Ray Astronomy, Black Hole Binaries, Solar X-Ray Astronomy, Instrumentation Related To X-Ray Astronomy And Solar / Planetary X-Rays, X-Ray Polarimetry, X-Ray Optics	A&A	PhD (2003)
222	Satyajit Seth	Asst. Professor	Theoretical High Energy Physics	THEPH	PhD (2014)
223	Satyendra Nath Gupta	Asst. Professor	Atomic Molecular and Optical Physics	AMOPH	PhD (2018)
224	Saurabh Suman	Jr. Pers. Assistant	Secretarial And Administrative Work	ADMDN	M.A Geography (2022)
225	Senthil Babu T.J.	Sr. Admn. Officer	All Establishment & Service Matters, General Administration	ADMGN	B.Sc. (1995)
226	Shaileshgiri I Goswami	Technician-F	Electrical Maintenance	CMDV	I.T.I (2013)
227	Shanmugam M Dy. Head-I, PSDN	Sci./Eng.-SF	Electronics Engineer, Design And Development of Space Instruments	PSDN	PhD (2017)
228	Shashank Urmalia	Sci./Eng.-SD	Mechanical Design For Ground Based And Space Instruments.	SPASC	B.E. (2014)
229	Shashi Kant	Sr. Assistant	CMG Office Assistantance	CMDV	B.Sc. (2016)
230	Shashikiran Ganesh	Professor	Milky Way Galaxy, Comets, Astronomical Instrumentation, Polarimetry	A&A	PhD (2010)
231	Shashi Prabhakar	Asst. Professor	Atomic Molecular and Optical Physics	AMOPH	PhD (2015)
232	Shibu K Mathew Head, USO	Sr. Professor	Solar Physics Solar Instrumentation	USO	PhD (1999)
233	Shital Hitesh Patel	Med. Officer-SF	Medical Management of Communicable And Non-Communicable Diseases	DISSR	M.D (1999)
234	Shivansh Verma	Sci./Eng.-SC	Geosciences	GSDN	MS (Integrated) (2021)
235	Shivanshi Gupta	Sci./Eng.-SC	Atomic, Molecular and Optical Physics	AMOPH	MS (Integrated) (2021)
236	Shiv Kumar Goyal	Sci./Eng.-SF	Planetary And Space Instrumentation For Radiation Measurements (Charged Particles, X-Rays, Gamma-Rays) And Mass Spectrometer	PSDN	M.Tech. (2019)

Sr. No.	Name	Designation	Specialization	Division	Highest Degree Obtained
237	Shreeya Natrajan	Sci./Eng.-SD	Organic Studies In Meteorites, Isotope Cosmochemistry, Spectroscopic Studies	PSDN	M.Tech. (2019)
238	Shreya Mishra	Sci./Eng.-SC	Atomic Molecular and Optical Physics	AMOPH	B.Tech. (2021)
239	Shreya Pandey	Sr. Assistant	Specialisation In PRL External Project Accounting, Preparation Of Fucs & Monthly Coins Compilation	ADMAC	M.Com. (2019)
240	Shubhra Sharma	Asst. Professor	Quaternary Geology, Geomorphology	GSDN	PhD (2017)
241	Smita Binoy Pillai	Purchase & Store Officer	Purchase & Stores	ADMPR	M.Sc. (2003)
242	Sneha Nair	Sr. Assistant	Purchase & Stores	ADMPR	M.SC. (2003)
243	Solanki Steven Alois	Purchase & Stores Officer	Purchase & Stores	ADMPR	B.C.A. (2011)
244	Som Kumar Sharma Dy. Head-II, SPASC	Professor	Atmospheric Dynamics, Weather And Climate, Long Term Changes, Lidar Probing Of Atmosphere	SPASC	PhD (2010)
245	Somabhai N Koted	Sr. Proj. Attendant	Cleaner and assistance in Director's office	ADMDIR	Fifth (1990)
246	Sonam Jitarwal	Sci./Eng.-SD	Electronics Engineer, Design And Development Of Space Based Instruments	PSDN	M.Tech. (2019)
247	Soumya Kohli	Sci./Eng.-SC	Astronomy & Astrophysics	A&A	M.S.(Integrated) (2022)
248	Srirag Narayanan Nambiar	Sci./Eng.-SD	Planetary Science, Ablation Physics, Numerical Modelling, Space Instrumentation	PSDN	B.E. (2017)
249	Srishti Sharma	Sci./Eng.-SD	Web Application Development, Database Management	CNIT	B.Tech. (2012)
250	Srubabati Goswami FNA, FASc, FNASc,FTWAS Head, THEPH	Sr. Professor	High Energy Physics	THEPH	PhD (1998)
251	Sujata Krishna	Sr. Proj. Attendant	Office assistance	ADMGN	S.S.C (1982)
252	Sunil D Hansrajani	Sr. Proj. Assistant	Stores / Purchase; Administration / Accounts	ADMST	B.Com (1991)
253	Sunil Kumar Singh FNA, FNASc	Professor	Isotope And Elemental Geochemistry	GSDN	PhD (1999)
254	Suraj Kumar	Sr. Assistant (ADHOC)	General Administration	ADMGN	B.Com (2015)
255	Sureshkumar K Patel	Senior Accounts Officer	Accounts services	ADMAC	M.Com (2014)
256	Sushil Kumar	Sci./Eng.-SD	Electronics Engineer: Design And Development Of Space Related Instruments	PSDN	B.Tech. (2014)
257	Suthar Pramodkumar	Technician-G	Workshop services	WORSH	D.M.E. (2016)
258	Swetapuspa Soumyashree	Sci./Eng.-SD	Laser Induced Breakdown Spectroscopy, Plasma Imaging, Femtosecond Physics,Payload Related Simulation In Simion And Comsol, Matlab Coding	AMOPH	B.E. (2017)
259	T A Rajesh	Sci./Eng.-SF	Atmospheric Aerosols, Black Carbon Aerosol Source Apportionment, Aerosol Radiative Forcing, Aerosol Chamber Experiment, Aerosol Instrumentation	SPASC	PhD (2019)
260	T K Sunilkumar	Sr. Tech. Assistant-D	Maintenance of trace gas analyzers	SPASC	B.Pharm (1991)
261	T. S. Neethu	Sr. Proj. Assistant	Administration And Stores	ADMST	M.Com (2007)
262	Tejas Narendra Sarvaiya Dy. Head, CNIT	Sci./Eng.-SF	Cyber Security, Server Virtualization, Linux/Unix Sysadmin, Network Administration, Shell Scripting, Website/Server Auditing.	CNIT	M.E. (2014)
263	Tinkal Ladiya	Sci./Eng.-SC	Electronics Design And Development For Space And Ground Application Instruments	PSDN	AMIE (2020)
264	V H Chavda	Technician-G	Masonary	CMDV	Ninth (1980)
265	V R Patel	Sr.Tech.-A	Workshop services	WORSH	Twelve (1985)
266	Vaibhav Dixit	Sci./Eng.-SE	Optical Designing, Astronomical Instrumentation, Adaptive Optics, H/W-S/W Interface, Data Analysis Pipeline, Simulation Software Development, Parallel Programing, Ai, Deep Learning, Linux Real-Time Scheduling	A&A	M.Tech. (2017)

Sr. No.	Name	Designation	Specialization	Division	Highest Degree Obtained
267	Vaibhav Varish Singh Rathore	Sci./Eng.-SD	Cyber Security, Linux And Unix System Admin, Network Management, Virtulization, Sever/Website Audit	CNIT	B.Tech. (2017)
268	Varun Sheel Head, PSDN	Senior Professor	Modeling Planetary Atmospheres	PSDN	PhD (1996)
269	Veeresh Singh	Asso. Professor	Active Galactic Nuclei (Agn) And Their Evolution, Radio Astronomy	A&A	PhD (2012)
270	Vibhor Agrawal	Scientist/ Engineer-SC	Planetary Sciences	PSDN	B.Tech (2023)
271	Vijaysinh Mansinh Rathod	Sr.Tech.-A	Electrical Repair and Maintance Works	CMDV	H.Sc. (1996)
272	Vikram Goyal	Sr. Sci. Assistant-A	Planetary Sciences, Isotope Cosmochemistry	PSDN	M.Sc. (2016)
273	Vimlesh Kumar	Sci./Eng.-SD	Mechanical, Photonics, Nonlinear Optics, Single Photons, Quantum Optics, Structured Optical Beams	AMOPH	B.Tech. (2016)
274	Vinayak Kumar	Sci./Eng.-SD	Astrophysics, Programming	AMOPH	B.Tech. (2013)
275	Vineet Goswami	Asst. Professor	Isotope Geochemistry, Geochronology, Chemical Oceanography, Non-Traditional Metal Stable Isotope Geochemistry, Inverse Modelling, Mass Spectrometry	GSDN	PhD (2012)
276	Virendra Kumar Padhya	Sci./Eng.-SE	Hydrology and IWIN Mass Spectrometery	GSDN	M.Tech. (2013)
277	Vishal Joshi	Asst. Professor	Astronomy & Astrophysics	A&A	PhD (2014)
278	Vishnu Kumar Dhaker	Sr. Sci. Assistant-A	Atmospheric Aerosols	SPASC	M.Sc. (2016)
279	Vishnubhai R Patel	Sci./Eng.-SD	In CAD Disign,CAM Programming, workshop services	WORSH	B.E. (2018)
280	Vivek Kumar Mishra	Sci./Eng.-SD	Mechanical Design,Telescope Mirror Coating & Cleaning,Mechanical Maintainance Of Eqipments	A&A	B.E. (2015)
281	Yogita Kadlag	Asst. Professor	Isotope Geology, Cosmochemistry and Mass Spectrometry	GSDN	PhD (2015)
282	Yugal Surendra Kumar Jain	Head Accounts	IFA	ADMAC	MBA(2009), CA (2013)


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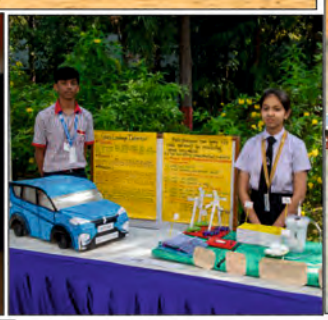


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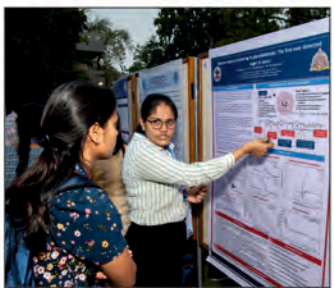




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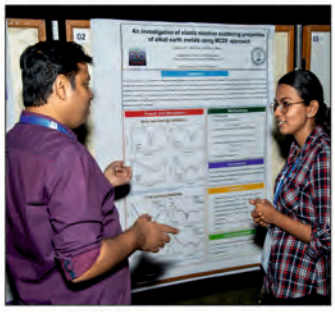
An investigation of elastic electron scattering properties of alkali earth metals using MCDF approach













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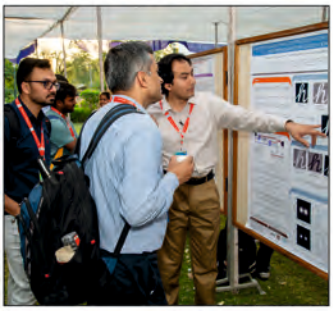

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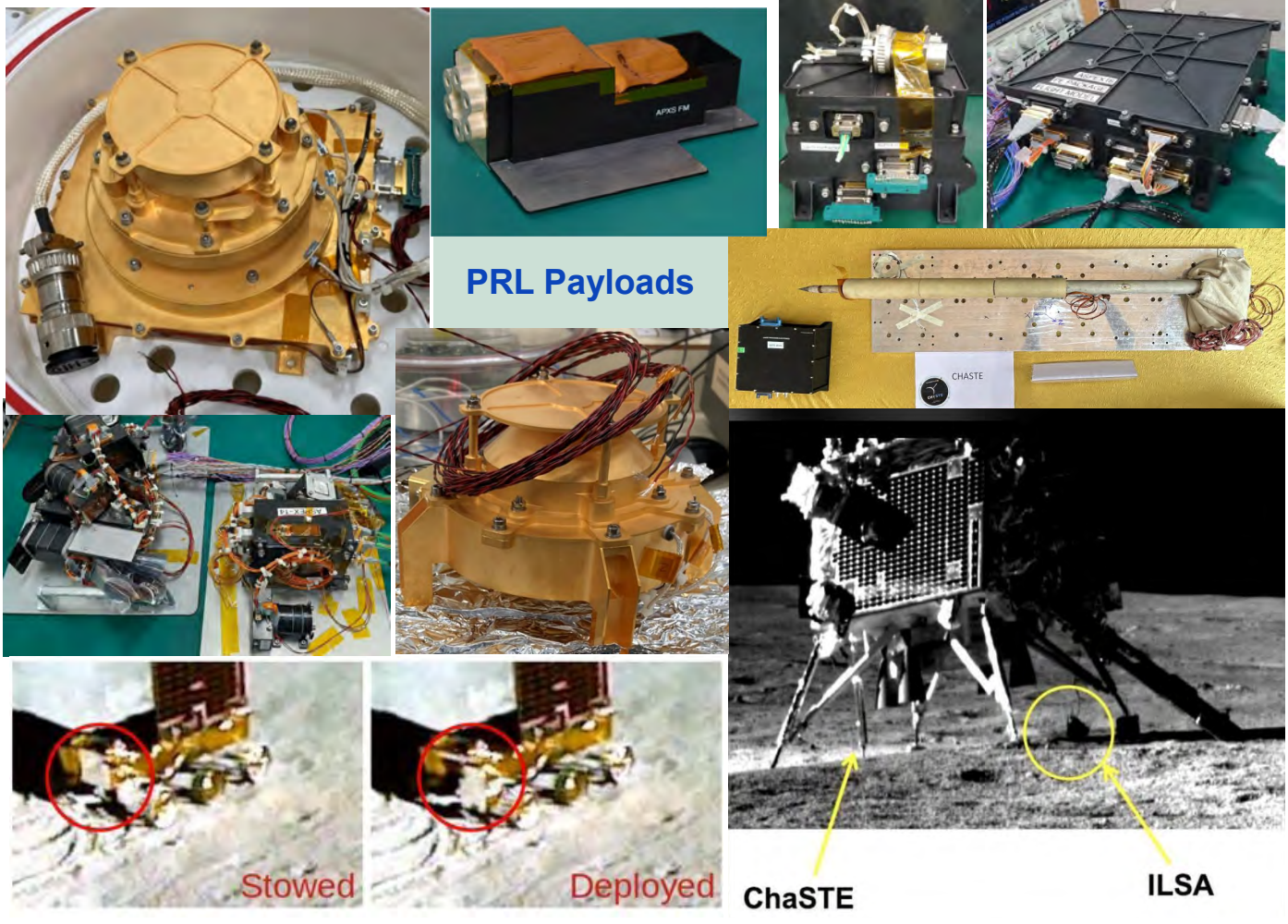
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