वार्षिक रिपोर्ट

ANNUAL REPORT

2007-2008

भौतिक अनुसंधान प्रयोगशाला, अहमदाबाद

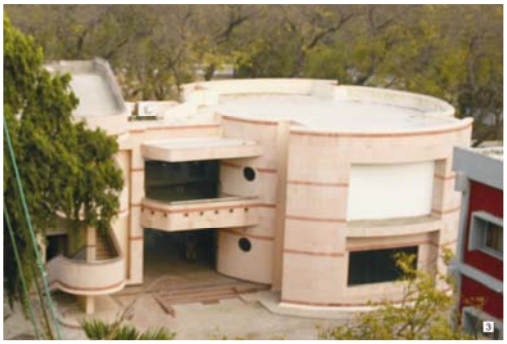
PHYSICAL RESEARCH LABORATORY, AHMEDABAD

वार्षिक रिपोर्ट

Annual Report

2007 - 2008

भौतिक अनुसंधान प्रयोगशाला, अहमदाबाद
Physical Research Laboratory, Ahmedabad



Compiled by :

Office of the Dean, PRL

Published by :

Physical Research Laboratory,
Ahmedabad

Layout by :

J. K. Burad Offset India Pvt. Ltd.

Printed by :

J. K. Burad Offset India Pvt. Ltd.

New Additions to PRL Campus

1. Students Hostel and Dining Hall, Thaltej Campus
2. Transit Hostel, Thaltej Campus
3. Nano-SIMS Laboratory and Lecture Hall, Main Campus

Council of Management

Chairman	
Professor U.R. Rao ISRO Headquarters, Govt. of India, Bangalore	Nominee, Government of India
Members	
Dr. G. Madhavan Nair Secretary, DOS, Chairman, ISRO, Govt. of India, Department of Space, Bangalore	Nominee, Government of India
Shri S.V. Ranganath, IAS Secretary, DOS Department of Space, Bangalore	Nominee, Government of India
Shri. Sanjay S. Lalbhai Ahmedabad Education Society	Nominee,
Shri Kartikeya V. Sarabhai Karmakshetra Educational Foundation	Nominee,
The Principal Secretary, Department of Education (Higher & Technical Education) Govt. of Gujarat, Gandhinagar, Gujarat	Nominee, Government of Gujarat
Prof. J. N. Goswami (Ex-Officio)	Director, Physical Research Laboratory, Ahmedabad
Member-Secretary	
Shri M. R. G. Murthy (Ex-Officio)	Controller / Registrar, Physical Research Laboratory, Ahmedabad

Contents

Director's Foreword, Events and Science Highlights

Director's Foreword

The Diamond Jubilee celebration of the Physical Research Laboratory (PRL), that started on November 11, 2006, continued during the current year with several events that included a couple of International Conferences and Diamond Jubilee Lectures by eminent persons in different fields.

PRL has made significant research contributions during the year in the areas of Astronomy, Solar Physics, Atmospheric and Space sciences, Earth and Planetary Sciences and Theoretical Physics. The laboratory is also contributing to the forthcoming Chandrayaan-1 mission through the design and development of one of the payloads and is also responsible for executing the science plans of this mission. The "Highlight" section of this report provide a glimpse of some of these; broader outline of the research activities carried out by the various Divisions of the laboratory are described in subsequent sections.

A major effort for induction of new faculty during the year led to nine young persons joining the PRL faculty. We look forward to them for providing fresh impetus and contributing significantly towards the research accomplishment of the laboratory. The number of research scholars has also been increased without compromising in quality. PRL currently has 61 Academic faculty, 20 Technical Faculty, 69 Research Scholars, 13 Post-doctoral Fellows, supported by 217 technical, administrative and other auxiliary personnel. The work done during the last year resulted in publication of 115 peer reviewed papers most of which about are in high impact factor international journals. PRL faculty members were invited to edit two monographs, write sixteen review articles and a single author graduate level book on "Particle and Astroparticle Physics". Eleven PhD Theses have been submitted during the year.

The scientific contributions of PRL faculty members have been recognized by peers from both within the country and beyond through the award of Fellowship of prestigious science academies that include Third World Academy of Sciences, Geochemical Society, European Association of Geochemistry, International Academy of Astronautics, Indian Academy of Sciences and Indian National Science Academy. PRL Faculty members have been invited to be members of Editorial Boards of several National and International Journals and also to serve as members in International and National Science Committees. Several younger members of PRL, including research scholars, also received recognition from the Indian Science Congress, Department of Science and Technology, and at several

National and International conferences.

Two successful International Conferences on "Aerosol-Chemistry-Climate Interactions" and on "Terrestrial Planets: Evolution through Time" were held during the year with significant participation of overseas scientists. Several national conferences, discussion meetings, workshops and schools on additional themes of interest were also held. PRL continued its HRD activities with active in-house doctoral and post-doctoral programmes, Associates programme for university and college teachers, summer programme for MSc students and training programmes for engineering graduates. Close to 23 MSc students, 4 teachers and 48 Engineering graduates have benefited from these programmes.

The celebration of Science day with various scientific programmes and competitive tests and interviews of students at all Gujarat level culminated with the award of Scholarship to five school students and additional incentives to other meritorious students. Efforts have also been made to accelerate progressive use of Hindi in administrative work and also in science communication through bilingual publication of PRL News. The Science out reach activities gained momentum, with atleast one major group from schools/colleges visiting every week for an audio-visual exposure to PRL Science and to interact with faculty and research scholars.

PRL hosted several distinguished persons during the year who have given lectures and interacted with the faculty and students during their stay at PRL. These include Prof. Guy P. Brasseur, Prof. M. S. Swaminathan, Dr. A. P. J. Abdul Kalam, Dr. C. Rengarajan and Dr. T. Ramasami. PRL also hosted a large number of visitors both from within India and abroad who came to interact with PRL faculty and students and to deliver colloquia and seminars.

PRL is also administering ISRO's RESPOND programme for Space Sciences and PLANEX programme for Planetary Science and Exploration. These programmes provide opportunity for scientists working at universities and other academic and research institutes to pursue research with support from ISRO. Currently both these programmes have more than twenty research groups in their fold. The PLANEX programme has also set up a National Facility for analysis of planetary materials with installation of three state of the art instruments.

Several expansion and renovation plans, that are completed or nearing completion, include major infrastructures at the Thaltej Campus at Ahmedabad and Udaipur Solar Observatory Campus and renovation of the facilities at Mt. Abu campus. These will go a long way in facilitating smooth implementation of the expanded scientific activities of the laboratory.

PRL has made major strides during the last year and I thank all the members of PRL for their devotion that made this possible. Effective implementation of the science proposals approved for the 11th Five Year Plan period will be a major challenge during the coming years. I am confident that with dedicated efforts from all we can accomplish the goals. I would like to record here my sincere gratitude to the PRL Council of Management for their sage counsel and guidance.

J. N. Goswami
Director

Science Highlights

Astronomy and Astrophysics

1. Detection of amorphous Alumina dust in the nova like object V4332 Sgr based on Infrared Observations using the Spitzer Space Telescope.
2. A study of characteristics of Coronal Mass Ejections (CMEs) and Solar flares based on SOXS and SOHO spacecraft data suggests that heating of solar coronal plasma is a prerequisite for the release of CMEs from flare reconnection regions.
3. Spectral variability on time scales of a few weeks to months in near infrared detected in a few highly evolved stars (Post Asymptotic Giant Branch stars), based on observations made at Mt. Abu Observatory, signify rapid thermal changes in their atmospheres.

Solar Physics

1. The major solar flare of October 28, 2003 led to enhanced velocity oscillations in the Sun in the higher frequency band (5 – 6.5 MHz), while it is not discernable in the low frequency band (2 - 4 MHz).
2. Source active region of the CME of November 18, 2003, that led to the strongest storm of Cycle-23, suggest that the region of flare/CME onset was marked by twisted non-potential low lying field lines compared to other regions.
3. Study of microflares, based on SOXS observations, revealed presence of Fe-line and suggests contributions from both thermal and non-thermal emissions making microflares a possible source of coronal heating.
4. The sign of helicity of the first few active regions of the new solar cycle follow the helicity hemispheric rule contrary to the expectations in certain dynamo theories.

Space and Atmospheric Sciences

1. An analysis of seasonal and spatial variations in aerosol characteristics over urban areas in India revealed seasonal changes in the effective sizes of particles and its effect on aerosol optical depths.
2. Distinctive effects of interplanetary electric field and substorm-related current systems on equatorial zonal electric field have been identified.
3. Boundary layer height over Ahmedabad determined from balloon borne measurements of air temperature

and humidity show highest height (Average 750 m) in summer and lowest height (Average 260m) in winter.

4. The electron density in northern and southern hemispheres of Mars is found to be different owing to the differences in the neutral density. The Martian dust is shown to deplete ion density.
5. Association and migration of atoms as well as changes in geometry are observed in molecular ions during electron impact ionization.

Planetary and Geosciences

1. Combined studies of fossil records of the now-extinct short-lived nuclides ^{26}Al and ^{60}Fe in meteoritic chondrules suggest that these nuclides were coinjected into the proto-solar cloud from a stellar source.
2. Analysis of two adjacent pieces of Kavarpura iron meteorite has revealed trapped solar wind noble gases indicating that they are residing in either non-metallic phases or the surface-cited solar wind component was not disturbed during formation of Kavarpura parent body.
3. The first data set on atmospheric abundances of Elemental Carbon (EC) and Organic Carbon (OC) over Northern & Western India suggest that total carbonec-eous aerosols contribute significan-tly (30–35%) to the Particulate Mass at urban locations.
4. Study of head water from Ganga (Alakananda, Bhagirathi, Ganga) coupled with inverse modeling led to quantification of the loss of Ca from these streams via calcite precipitation during lean flow.
5. Iron-enrichment experiment conducted in the Southern Indian Ocean using ^{15}N tracer technique shows that though iron enrichment increase the productivity in High Nutrient Low Chlorophyll regions, there is no monotonic increase in the export productivity.
6. Two sediment cores raised from central and the southern Bay of Bengal, dated by AMS radiocarbon and analyzed for Sr and Nd isotopes suggest that during the Last Glacial Maximum (LGM), the strengthening of North-East monsoon brought high sediment flux from the Arakan Coast through Irrawaddy River.
7. Palaeoseismic studies carried out on samples from the Great Rann of Kachchh using Thermolu-minescence (TL) and Optically Stimulated Lumine-scence (OSL) dating techniques suggest a possible recurrence interval of close-to-thousand years for earthquake of large magnitude (Mw ~8).

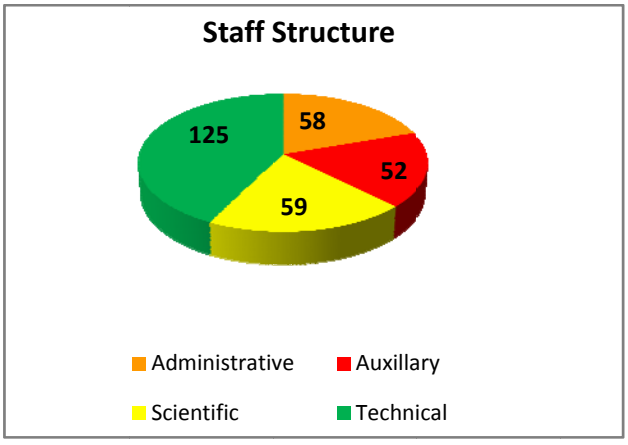
Planetary Science and Exploration Programme

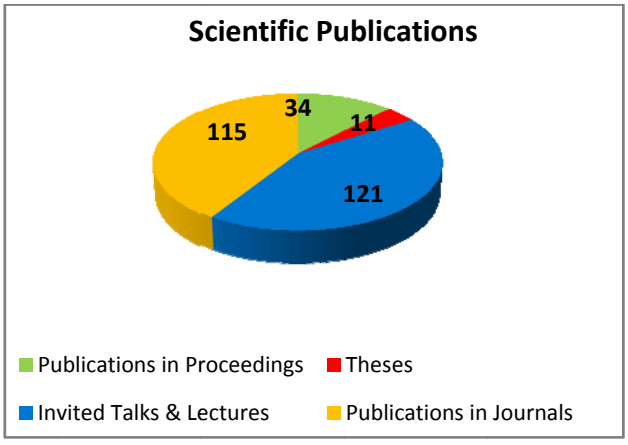
1. High Energy X-gamma ray payload (HEX), to map natural radiation from lunar surface in the range of 30-270 keV, has been developed for the Indian Moon mission Chandrayaan-1. The principal objective of HEX is to map the abundance of the radioactive isotope ^{222}Rn over the lunar surface, with emphasis on the polar region, as a tracer to understand volatile transport process on the Moon.
2. Galactic Cosmic Ray (GCR) induced radiation dose rate in Martian surface soils up to a depth of few meters has been estimated under different solar modulations conditions. The results suggest that estimation of deposition ages of Mars soils based on Luminescence studies will be feasible only for deep-seated soils.

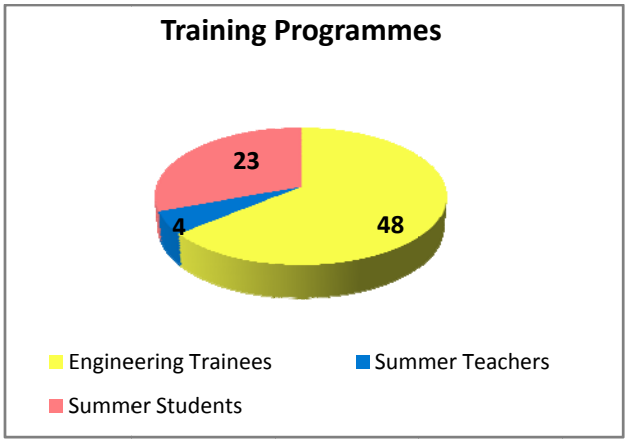
Theoretical Physics

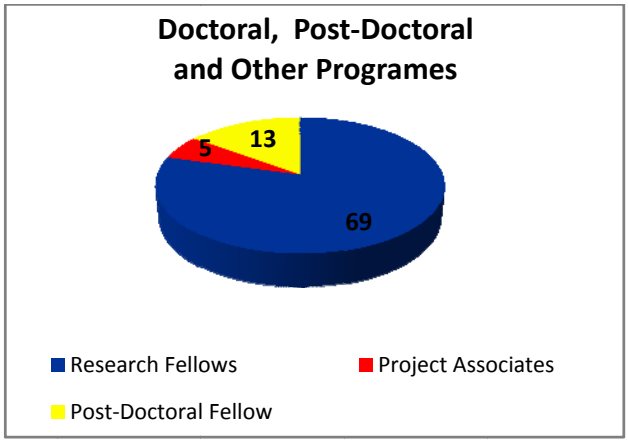
1. A Specific scenario relating the dark energy of the universe to the existence of nearly massless "pseudo Goldstone bosons", which also play important role in generating neutrino masses, is proposed.
2. The specific realization of the hypothesis of the minimal flavour violation which attributes CP violation to CKM matrix as in standard model.
3. It is shown that the linear collider with polarized electron positron beams would be quite useful in studying the couplings of the Higgs boson to two Z's or to a photon and a Z.
4. Properties of a new state of the coupled dynamical system behaving like a spin glass state were studied. It was shown that in such a state a even though individual variables evolve dynamically in a chaotic fashion, the system shows a definite ordering of variables.
6. The statistical spectral distribution method (SDM) and mean-field deformed shell model (DSM) method developed in PRL for nuclear structure studies were used to obtain beta decay and double beta decay half lives for some medium heavy nuclei (A ~60-80).
7. The vortex formation using polarized light was studied. It was shown that the forked holographic grating changes the polarization in the process of forming the vortex.
8. Analytical prediction and results from measurements with a multimode waveguide interferometer operating in a fibre-coupled, dual-mode regime suggest possibility of fringe spacing of $\lambda/130$, which is an order of magnitude better than previous results.

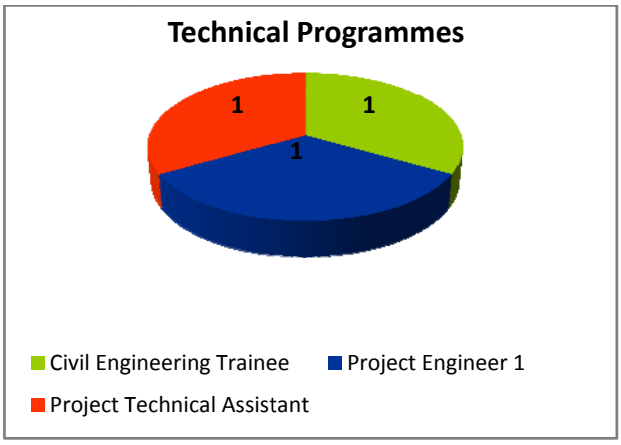
Human Resource Development

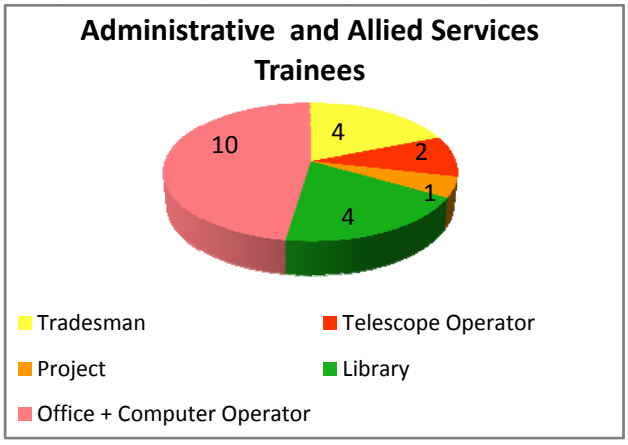












*As on 31st March, 2008

Events at PRL

Distinguished Visitors/Lectures

Diamond Jubilee Lectures

Indian Economy: Challenges and Opportunities
Dr. C. Rangarajan
Chairman,
Economic Advisory Council to the Prime Minister.

Long term Horizons of Indian Science:
A Planner's Perspective
Dr. T. Ramasami
Secretary,
DST, New Delhi.

K. R. Ramanathan Professorship

The Earth's Climate in the 21st Century
Prof. Guy P. Brasseur
NCAR, Boulder, Colorado, USA.

Vikram A. Sarabhai Professorship

Cosmic Rays and Human Space Travel
Prof. E. Parker
University of Chicago, USA.

INSA/PRL/GSA/IPA Lectures

Challenges of being a scientist: A life of toil and fun
Prof. D. Lal
Scripps Institution of Oceanography, USA.

A Scientist's Search for the Truth
T. Gehrels
Univ. of Arizona, USA.

Fascinating dynamics and chaos in the flow of soft matter
Prof. A. K. Sood
IISc, Bangalore.

Wonders and Challenges of Plasma Science
Prof. Abhijit Sen
Institute for Plasma Research, Gandhinagar.

The Challenges of New Horizons in Basic Sciences
Prof. G. K. Mehta
Honorary Eminent Scientist,
Inter University Accelerator Centre, New Delhi and
Distinguished Honorary Professor,
Indian Institute of Technology, Kanpur.

Awards Conferred by PRL

Hari Om Ashram Prerit Senior Scientist Award was given to Prof. M. S. Swaminathan, FRS, M. S. Swaminathan Research Foundation, Chennai.

Buti Foundation Award for the year 2007 in the field of Plasma Science & Technology (instituted at PRL by Buti Foundation, New Delhi) was given to Dr. Subroto Mukherjee, Institute of Plasma Research, Ahmedabad.

Awards and Honours
Conferences and Lectures

Awards and Honours

U. R. Rao

1. D. Sc (hon. causa) IIT Delhi 2007
2. Elected, Fellow World Academy of Sciences and Arts, USA
3. A V Ramarao Technology Award 2007 by Indian Institute of Chemical Technology, Mumbai and AVRA technologies, Hyderabad

J. N. Goswami

1. Council Member, National Academy of Sciences, Allahabad
2. Fellow, Geochemical Society
3. Fellow, European Association of Geochemistry
4. Member, International Academy of Astronautics

A. K. Singhvi

1. K. Naha Medal 2007 of Indian National Science Academy
2. President, Luminescence Society of India (2008-2010)
3. Member, Editorial board, Current Science, India
4. Member Editorial Board, Open Geology Journal, UK
5. Chair, INSA-Indian National Committee for IUGS, SCL and INQUA

M. M. Sarin

1. Fellow, Indian National Science Academy
2. Member, Editorial Board, Indian Journal of Marine Sciences
3. Member, Executive Committee of Indian Aerosol Science & Technology association (IASTA)
4. Member, UN/GESAMP Working Group No. 38
5. Adjunct Professor, College of Marine & Earth Studies, University of Delaware (U.S.A)

R. Ramesh

1. Fellow, Third World Academy of Sciences, Trieste, Italy

S. D. Rindani

1. Fellow, Indian National Science Academy

U. Sarkar

1. Fellow Indian Academy of Sciences, Bangalore

S. Krishnaswami

1. Member, Governing Council, Wadia Institute of Himalaya Geology, Dehradun
2. Chairman, INSA National Committee for IGBP, WCRP and SCOPE

V. K. B. Kota

1. Adjunct Professor, Department of Physics and Astronomy, Laurentian University, Sudbury, Canada

Ashok Ambastha

1. Co-Director, First Asia-Pacific Regional International Heliospheric Year School, Kodaikanal, December 7-22, 2007
2. Member of INSA National Committee on COSPAR-URSI- SCOSTEP
3. Member Solar Task Group, International Living with a Star (ILWS)

B. G. Anandarao

1. Member, Editorial Board, "Astrophysics and Astronomy Insights", New Zealand

N. Juyal

1. Member, Programme Advisory Committee – Earth Sciences, DST, New Delhi
2. Member , Study Group on Himalayan Glaciers, Government of India

J. P. Das

1. "Young Scientist" award for paper presentation, 9th International Conference on Gas Geochemistry, Taipei, Taiwan, October. 1-8, 2007

Manish Tiwari

1. Indian Science Congress Young Scientist Award 2007

Rohit Srivastava

1. First prize for paper presentation European research Course on Atmospheres, Grenoble, France, February, 2008

Y. C. Nagar

1. Young Scientist Award, Department of Science and Technology Earth Science, New Delhi

Conference/Symposia/Workshops

Conferences / Symposia

1. **International conference on "Terrestrial Planets: Evolution through time",** January 22-25, 2008.

   with 94 participants including 32 from overseas.

2. **Discussion meeting on "Possible experiments on future Moon Missions",** September 13-14, 2007.

   with participation of 77 scientist including one from overseas.

3. **International symposium on "Aerosol-Chemistry-Climate Interactions**", November 20-22, 2007.

   with participation of 103 scientist including 19 from overseas.

4. **Symposium on, "Science and exploration on Venus and Mars" ,** July 31-August 4, 2007

   during Asia Ocenia Geosciences Society meeting held in Bangkok, Thailand with 20 participants.

5. **Fourth National Conference on "Nonlinear Science and Dynamics"**, January 3-5, 2008. with 72 participants including 10 from overseas.

Workshops / Schools

1. **A ISRO-GBP brainstorming workshop on "High resolution Paleoclimate and Paleomonsoon reconstruction for the last 20 Ka",** July 20-22 2007.

   Jointly arranged by PRL and Cochin University of Science and Technology with participation of 25 scientists.

2. **International workshop, "GEOTRACES Indian Ocean Planning Workshop**" Goa October 23-26 2007.

   Jointly organized by PRL and NIO (Goa), and Sponsored by Ministry of Earth Sciences, New Delhi with 60 participants including 20 from overseas.

3 **8th PLANEX WORKSHOP on "Exploration of Solar system objects"** at pondicherry December 24-28 2007.

   Participation of 35 M.Sc/B.Tech, young researchers. Jointly organized by PRL and Pondicherry University.

Invited Talks

Astronomy and Astrophysics

B.G. Anandarao

1. "Universe in Near-Infrared Wavelengths", in the series Vistas in Astronomy, Nehru Planetarium/ Nehru Centre, Mumbai, 6 October, 2007.
2. "Molecular Hydrogen Diagnostics in Astronomy", Symposium/Conference on Atomic and Molecular Physics, S.P. University, Vallabh Vidyanagar, 3-5 January 2008.

Hari Om Vats

3. "Space weather consequences of solar wind extremes, Super active regions of solar cycle 23 and their geo-space impact", ARIES Nainital, 07-10 May, 2007.
4. "Recent observations of WD1524 at MIRO and possible participation in future WET program", DARC/WET Workshop, Mt Cuba Observatory (USA), 1-3 August, 2007.
5. "Observations of shadow bands during a total solar eclipse in the perspective wave scattering by turbulence", DMAS Ashton Observatory (USA), 11 August, 2007.

N.M. Ashok

6. "Eruptive Variables", IUCAA Workshop on Observations with small telescopes, Bhavnagar University, 19-21 November, 2007.

Rajmal Jain

7. "Initial Results from Hinode Mission" Takeo Kosugi and INDO-Japan Collaboration in Solar Physics, workshop held at National Astronomical Observatory of Japan, Mitaka, Tokyo, Japan, 24-27 April, 2007.
8. "Recurrent Solar Activity in Super Active Region NOAA 10656", at IHY-CAWSES International Workshop held at Aryabhatta Research Institute for Observational Sciences (ARIES), Nanital, 7-10 May, 2007.
9. "Solar X-ray Spectrometer (SOXS)" Mission onboard GSAT-2 Indian Spacecraft at Nanjing Institute of Astronomical Optics and Technologies/ NAOC, Nanjing, 9 August, 2007.
10. "Techniques to Observing Sun in X-ray and EUV Emission" at National Astronomical Observatories, Chinese Academy of Sciences (NAOC), Kuming, 13 August, 2007.

11. "Solar X-ray Spectrometer (SOXS) Mission and Exploring New Initiatives for Chinese SST" at National Astronomical Observatory, Chinese Academy of Sciences (NAOC), Beijing, China, 27 August, 2007.

12. "The Sun in X-rays: SOXS Mission" at PLANEX Workshop on Exploration of Solar System Objects, Pondichery University, 24-28 December, 2007.

13. "Charged Particle Spectroscopy" at PLANEX Workshop on Exploration of Solar System Objects, Pondichery University, 24-28 December, 2007.

T. Chandrasekhar

14. "Measuring the sizes of stars", IUCAA Workshop on Observations with small telescopes, Bhavnagar University, 19-21 November, 2007.

15. "Measuring the sizes of stars", IUCAA Workshop on Observations with small telescopes, Bhavnagar University, 19-21 November, 2007.

16. "Asteroids and Comets" at the VIIIth Planex Workshop on Exploration of the Solar System Objects, Pondicherry University, 24-28 December, 2007.

U.C. Joshi

17. "Probing dust in Comets – Polarisation Observations in visual bands and mid IR Spectrum" at Workshop on Light Scattering methods in Dust Modelling, S.N. Bose National Centre for Basic Sciences, Kolkatta, 28-29 November, 2007.

Planetary and Geosciences

J. N. Goswami

18. "A mixed or a stratified nebula?: What the chondrule tells us" TIARA Workshop on "Mixing in the early solar system" Taiwan, 30July-3 August, 2007.

19. "Time of onset and duration of chondrule formation", 70th Annual Meeting of the Meteoritical Society, Arizona, USA, 13-17 August, 2007.

20. "Planetary science and exploration: An Indian perspective", International Aeronautical Congress, Hyderabad, 23-29 Sept., 2007.

21. "Frontier areas of research in solar system studies" Annual meeting of the Indian Academy of Sciences, Trivandrum, 1-4th November, 2007.

22. "Planetary Exploration Programme: Challenges and Opportunities", PLANEX workshop on Exploration of solar system objects, Pondicherry University, 24-28 December, 2007.

23. "Chandrayaan-1: India's first planetary mission", International Conference on "Terrestrial Planets: Evolution through time", PRL, Ahmedabad, 22-25 January, 2008.

24. "Planetary Exploration: An ISRO Perspective" Jet Propulsion Laboratory, Pasadena, USA, 5 February, 2008.

A.K. Singhvi

25. "The Geology of Tsunamis: Some Thoughts on a Coordinated National Program", Indian National Centre for Ocean Information Services, May, 2007.

26. "The social dimensions of Geosciences", INSA seminar on International Years, Indian National Science Academy, October, 2007.

27. "Luminescence dating : An example of synergistic mutualism between Physics and Geology", International seminar on Luminescence and its applications, NPL, February, 2008.

28. "Chronology of sediments and reconstruction of past climatic- and paleo-seismic events: Land-Sea Correlations", International Conference on Terrestrial Planets: Evolution through time, PRL, 22-25 January, 2008.

29. "Climate Change, Earth Surface Processes and Human Impact: Relevance of Paleo-records towards planning the future", Forum on Climate Change and Science & Technology Innovation, Chinese Academy of Sciences, Beijing 2008.

K.K. Marhas

30. "Stardust Mission" International Conference on 'Terrestrial Planets: Evolution Through Time', PRL, Ahmedabad 22-25 January, 2008.

31. "Stardust" Eighth PLANEX workshop on 'Exploration of solar system objects', Pondicherry University, Pondicherry 24–28 December 2007.

32. "Mass spectrometry in planetary exploration" Eighth PLANEX Workshop on 'Exploration of solar system objects', Pondicherry University, Pondicherry 24–28 December 2007.

M.M. Sarin

33. "Atmospheric dust and anthropogenic trace element inputs to the tropic Indian Ocean"; GEOTRACES Indian Ocean Planning Workshop, Goa, 24-26 October, 2007.

34. "Characteristics and sources of atmospheric carbona-

ceous species over Indian region"; IASTA-2007 Conference on Emerging Trends in Aerosols: Technology and applications, NPL, New Delhi, 14-16 November, 2007.

35. "Mineral aerosols and atmospheric chemical transformations in high-dust regions"; International symposium on Aerosol-Chemistry-Climate, PRL, Ahmedabad, 20-22 November, 2007.

36. "Paleo-productivity and carbon burial records from Arabian Sea using multi-tracer approach"; International Conference on Terrestrial Planets: Evolution through time, PRL Ahmedabad, 22-25 January, 2008.

R. Ramesh

37. "Ocean fertilization: recent results from the southern Ocean", National conference on carbon dioxide mitigation, Andhra university, Visakhapatnam, 21-22 September, 2007.

38. "Holocene Monsoon variations in the South Asian region", Conference on "Celebrating the Monsoons", IISc, Bangalore, 26 July, 2007.

39. "Holocene monsoon reconstruction using speleothems", Conference on Asian Monsoon Variability during the Past Global Changes, Nainital, 11-14 September, 2007.

40. "Continental-scale differences in the Holocene monsoon rainfall over Asia: speleothem oxygen isotope records", International Conference on "Terrestrial Planets: Evolution through time", PRL, 22-25 January, 2008.

41. "Monsoon reconstruction from various archives using stable isotopes", TWAS Annual meeting, Trieste, Italy, 15 November, 2007.

S. Krishnaswami

42. "Chemical and Physical Erosion in the Southern slopes of the Himalaya, Ganga plain and Deccan Traps: A synthesis", Intl. Conf. Terrestrial Planets: Evolution through Time, PRL, 22-25 January, 2008.

43. "Erosion in River Basins of India: Causes and Consequences", CSIR Foundation Day Talk, National 1Institute of Oceanography, Goa, 26 September, 2007.

S. V. S. Murty

44. "'Cosmic ray exposure records of Martian meteorites" 4th annual meeting of Asia Oceania Geosciences Society, Bangkok, Thailand, July 31-August 4, 2007.

45. 'Solar System Origin' 8th Planex workshop on "Exploration of solar system objects", Pondichery University, Pondichery, 24-28 December, 2007.

46. 'Missions to Asteroids and Comets' 8th Planex workshop on "Exploration of solar system objects", Pondichery University, Pondichery, 24-28 December, 2007.

Sunil Kumar Singh

47. "Erosion and Weathering in the Himalaya", Conference on Himalayan Rivers & Climate Change, India International Centre, New Delhi, 11 February, 2008.

Planetary Science and Exploration Programme

D. Banerjee

48. "Planetary Remote Sensing and new lunar missions", National Seminar on Modern Trends in Geophysical Sciences and Techniques, Indian School of Mines, Dhanbad, 12-14 November 2007.

Solar Physics

Ashok Ambastha

49. "Solar Interior", First Asia-Pacific Regional International Heliospheric Year School, Kodaikanal, 17-18 December, 2007.

Nandita Srivastava

50. "Logistic Regression Model for Predicting Space Weather: Success, Constraints and Challenges", the Fourth Asia Oceania Geosciences meeting (AOGS), Bangkok, July 29-August 4, 2007.

51. "On the propagation of coronal mass ejections causing major geomagnetic storms", the Fourth Asia Oceania Geosciences meeting (AOGS), Bangkok, July 29-August 4, 2007.

52. "Techniques for 3d Reconstruction of CME Leading Edge using COR1/SECCHI images", Prominence Observations and Models Workshop (PROM 2007), University of California, Berkeley, USA, 29-30 October, 2007.

53. "Progress on Ground-based Dual Beam H-alpha Doppler System at Udaipur Solar Observatory", Prominence Observations and Models Workshop (PROM 2007), University of California, Berkeley, USA, 29-30 October, 2007.

54. "Coronal mass ejections from Sun in 3-D: Early Results from the Coronagraph COR1 aboard STEREO" Colloquium given at Indian Institute of Astrophysics, Bangalore, 29 January, 2008.

Sanjiv Kumar Tiwari

55. ''Evolution of Helicity in the Sun'', First Kodai – Trieste Workshop on Plasma Astrophysics, at Indian Institute of Astrophysics, Kodaikanal Observatory, India, August 27 - September 7, 2007.

Space and Atmospheric Sciences

B. Bapat

56. "Alteration of Molecular Structures during Dissociative Ionisation" Meeting on Intense Laser-Matter Interaction, at Tata Institute of Fundamental Research, Mumbai. 16-18 October 2007.

D. Pallamraju

57. "Space Weather Effects on the Geospace" in National Symposium on Emerging Trends in Space and Aviation Meteorology, New Delhi during 18-19 February, 2008.

58. "Response of daytime OI 630.0 nm emissions due to Solar Wind-Ionosphere-Thermosphere Interactions", in National Space Science Symposium, Ooty during 27-29 February, 2008.

K.P. Subramanian

59. "Evolution dynamics of laser produced plasma plumes and its applications" at Topical Conference on Atomic and Molecular Physics, S. P. University, Vallabhavidhyanagar 03-05 January, 2008.

S. A. Haider

60. "The longitudinal distribution of lower ionosphere of Mars at high latitudes", AOGS 2007, held in Bangkok, Thailand, July 31-August 4, 2007.

61. "Exploration of atmospheres of Mars and comets", 8th PLANEX workshop held in University of Pondichery, Pondichery, 24-28 December, 2007.

62. "Cassini and Huygen's probe to Titan", 8th PLANEX workshop held in University of Pondichery, 24-28 December, 2007.

S. Lal

63. "Tropospheric ozone and related trace gases: Impact of heterogeneous chemistry", Indian Aerosol Science and Technology Association symposium, NPL, Delhi, 13 November, 2007.

S. Ramachandran

64. "Aerosol impact on climate: Complexity and challenges in modeling", India-EU Grid workshop, Centre for Development of Advanced Computing, Pune, 27-28 September, 2007.

65. "Atmospheric aerosols: Radiative forcing and climate impacts", Indian Institute of Tropical Meteorology (IITM), Pune, 26 September, 2007.

66. "Atmospheric aerosols: Radiative forcing, issues and climate impacts", Aryabhatta Institute of Observational Sciences (ARIES), Nainital, 17 October, 2007.

67. "Aerosol radiative forcing and climate impact: Parameters and Challenges", International Symposium on Aerosol-Chemistry-Climate Interactions, Physical Research Laboratory, 20-22 November, 2007.

68. "Aerosol radiative forcing and climate impact", Climate Science and Policy Workshop, Thailand, 12-13 January, 2008.

Theoretical Physics

D. Angom

69. "Atoms in isolation and company", Seminar on Trends in Computational Materials Science, JNCSAR, Bangalore, 15-17 February, 2007.

70. "BEC in dilute atoms", Regional meeting of IAPT, SP University, Anand, 11 April, 2007.

H. Mishra

71. "Relativistic BCS BEC cross over in quark matter", invited working group talk in X Workshop in High Energy Physics Phenomology, Institute for Mathematical Sciences, Chennai, 2-13 January, 2008.

J. Banerji

72. "Revivals and fractional revivals of atomic and molecular wave packets", Topical Conference on Atomic & Molecular Physics - TC 2008, Sardar Patel University, Vallabh Vidhyanagar, 3-5 January, 2008.

73. "Schrödinger cats in phase space", Workshop on coherent control, IIT, Kanpur, 9-10 July, 2007.

P. K. Panigrahi

74. "Solitons in BEC and their coherent control" in XVI

National Conference on Atomic and Molecular Physics, TIFR, Mumbai, 8-11 January, 2007.

75. "Periodicities in financial time series: A wavelet perspective", in International Conference on Econo-Physics, Saha Institute of Nuclear Physics, Kolkata, 11-15 March, 2007.

76. "Sub-Planck structure of entangled cat-states", in Conference on Quantum Optics & Quantum Information, JNU, Delhi, 16-18 March, 2007.

R. E. Amritkar

77. "Glassy state of coupled dynamical systems" 16-27 July, 2007.

78. "Synchronization in networks" Conference and Research Workshop: Perspectives on Nonlinear Dynamics, International Centre for Theoretical Physics, Trieste, Italy 16-27 July, 2007.

79. "Synchronization of networks" International Workshop and conference on Statistical Physics Approach to Multi-disciplinary problems, Indian Institute of Technology, Guwahati, 7-13 January, 2008.

80. "Glassy state of coupled dynamical systems" in the International Conference on Recent developments in Nonlinear Dynamics, Bharathidasan Univ, Tiruchirapalli, 13-16 February, 2008.

R. P. Singh

81. "Vortices of light: lines of darkness", at Oregon Center for Optics, University of Oregon, 24 September, 2007.

82. "Optical Vortices: Propagation and Coherence", Workshop on Coherent Control, IIT, Kanpur, 9-10 July, 2007.

83. "Cigarette smoke aerosols- particle size and health hazards", International Workshop on Physics in Biology: A Synergy (IWPBS2007), School of Physics, University of Hyderabad, Hyderabad 12-14 December, 2007.

V.K.B. Kota

82. "Spectral Distribution Method for Neutrinoless Double Beta Decay Nuclear Matrix Elements" in the Workshop on "Neutrinoless Double Beta Decay ($0\nu\beta\beta$)", Tata Institute of Fundamental Research, Mumbai, 26-27 October, 2007.

Lectures at Universities/Institutions

Astronomy and Astrophysics

Hari Om Vats

1. "Scientific analysis of the mysterious sight at Maitri", (in Hindi), Institute of Plasma Research, Ahmedabad, 13 September, 2007.

Rajmal Jain

2. "Probing the Solar Corona with SOXS" at XRT-Hinode Workshop, Udaipur Solar Observatory/ PRL, Udaipur, 9 July, 2007.
3. "The X-ray Sun" at Dept. of Physics, Barkatullah University, Bhopal, 12 October, 2007.
4. "The Solar and Terrestrial Environment" at Dept. of Physics, Jivaji University, Gwalior, 20 October, 2007.

Planetary and Geosciences

K.K. Marhas

5. "Fe isotopic composition from supernova grains", Max-Planck Institute für chemie, Mainz, Germany, July, 2007.

M.M. Sarin

6. "Dating of rocks and sediments by radioactive methods" (2 Lectures); Refresher Course on Marine Geology of Geophysics, NIO, Goa, 22 October, 2 November, 2007.
7. "Application of radioactive isotopes in Oceans" (1 Lecture); Refresher Course on Marine Geology & Geophysics, NIO, Goa, 22 October, 2 November, 2007.
8. "Atmospheric nano-particles: Some environmental issues" Post-Graduate Teachers' Refresher Course", School of Environment, Gujarat University, February, 2008.
9. "Atmospheric Chemistry: Implications to climate change" Post-Graduate Teachers' Refresher Course, School of Chemistry Gujarat University, February, 2008.

R. Ramesh

10. Three talks on "Stable isotope systematics, applications to Oceanography", Refresher Course on Marine Geology and Geophysics, NIO, Goa 29-30 October, 2007.

Solar Physics

P. Venkatakrishnan

11. "The Story of Solar Magnetism", Kothari Jayanti Celebrations, S.I.E.R.T., Udaipur, 6 July, 2007.

Space and Atmospheric sciences

H. Chandra

12. "Earth's Ionosphere" (13 lectures), Gujarat University : Space Science course, October-December, 2007.
13. "Ionosphere and techniques", (8 lectures), Saurashtra University, Rajkot, 21-25 January, 2008.
14. "Planetary Atmospheres", (2 lectures), International IHY School, IIA Kodaikanal, December, 2007.
15. "Day to day variability of ionosphere at low latitudes on quiet and disturbed days", IIT Roorkee, September, 2007.

R. Sekar

16. "Airglow techniques to explore upper atmosphere", (5 lectures), Gujarat University, Ahmedabad, November, 2007.

S. Lal

17. "Ozone and trace gases over the Indian region", Aerosol Chemistry Climate Interactions, Gujarat University, Ahmedabad, 20 November, 2007.
18. "Recent results related to trace gases observed over India", University of Maryland, 29 February, 2007.
19. "Global warming: Role of Atmospheric Gases", State Institute of Public Administration, Jodhpur, 15 February, 2008.
20. "Atmospheric Chemistry over India", Tokyo University, 20 April, 2007.

S. Ramachandran

21. "Atmospheric aerosols", Gujarat University, 10 October, 2007.
22. "Atmospheric optics, Atmospheric aerosols, and Atmospheric Chemistry and Modeling", 5 Lectures, Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital, 15-19 October, 2007.

Som K. Sharma

23. "Importance of Lidar in Atmospheric Studies" Scared Heart Degree College, Sitapur, 26-27 September, 2007.

Varun Sheel

24. "Earth's Neutral Atmosphere", 8 Invited lectures, Gujarat University, 17-31 September, 2007.
25. "Modelling Chemical, Radiative and Dynamical processes in the lower atmosphere", 5 Invited Lectures, Aryabhatta Research Institute of Observa-tional Sciences, Nainital, 14-18 January, 2008.
26. "Modeling Atmospheric Chemistry in the Lower Atmosphere", Colloquium, Aryabhatta Institute of Observational Sciences (ARIES), Nainital, 16 January, 2008.

Theoretical Physics

D. Angom

27. "Bose Einstein condensation in quartic potentials", Topical conference on atomic and molecular physics 2008, SP University, Anand, 3-5 January, 2008.

H. Mishra

28. "Superconductivity in neutron star matter", in Phyics Department, Berhampur University, Orissa, 17 August, 2007.
29. "Gapless superconductivity from quark matter to cold atoms", Colloquium, Tata Institute of Fundamental Research, Mumbai, 18 September, 2007.

J. Banerji

30. "Exploring fractional revivals and sub-Planck structures in phase space with Wigner and Kirkwood", Colloquium given at Indian Association for the Cultivation of Science, Kolkata, on 26 September, 2007 and at Bose Institute, Kolkata on 25 April, 2008.
31. "Novel Resonators and Interferometers based on Self-Imaging Waveguides", Colloquium given at Indian Institute of Science Education and Research, Kolkata on 23 April, 2008.

R. E. Amritkar

32. "Synchronization of coupled dynamical systems", in Hands-on Research on Complex Systems -- Winter school, Institute of Plasma Research, Ahmedabad, 6-18 January, 2008.

R. P. Singh

33. "Optical Vortices: Generation, Characterization and Applications", at Physics Department, City College of New York, 5 October, 2007.

34. Optical Vortices and their Applications", Department of Physics, University of Arkansas, 28 September, 2007.

Library and Information Services

Nishtha Anilkumar

35. "Managing knowledge through institutional repository" during the UGC Refreshers' Course organized by Gujarat University, for the Practicing college librarians of Gujarat, in June, 2007.
36. "Best Practices devised at PRL Library" during a seminar organized by ADINET, Ahmedabad in September, 2007.
37. "Copyright in Digital Environment" during the UGC Refreshers' Course organized by Saurashtra University, Rajkot, for the practicing college librarians of Gujarat, in February, 2008.

Computer Centre

Jigar Raval

38. Delivered expert lectures on Open Source techno-logy Linux and System Administration by Jigar Raval during UGC approved refreshers course for MCA/BCA/Electronics faculties at Gujarat University during 19-22 November, 2007.
39. Presentation on Linux Server Security by Jigar Raval during the Workshop on Linux Network and System Administration Computer Society of India, Ahmedabad Chapter and Red Hat during 26-28 January, 2007.

Theses submitted

1. **Gosain Sanjay**

   Polarimetric Studies of the Solar Atmosphere. (2007) Mohanlal Sukhadia University, Udaipur.

2. **Kumar Brajesh**

   Study of Inhomogeneities in the Solar Atmosphere. (2007) Mohanlal Sukhadia University, Udaipur.

3. **Sharma Vandana**

   Momentum Spectroscopic Studies of Atomic and Molecular Ionisation. (2007) Mohanlal Sukhadia University, Udaipur.

4. **Morthekai P.**

   Investigations on the radiation dose distribution in natural environment and their implications in luminescence chronology. (2007) Gujarat University.

5. **Chakrabarty Dibyendu**

   Investigation On The F Region Of Inosphere Over Low Latitudes Using Optical, Radio And Simulation Techniques. (2007) Mohanlal Sukhadia University, Udaipur.

6. **Gowda Rudraswami N.**

   Isotopic Studies on evolution of early solar system object By Ion Microprobe. (2007) Gujarat University.

7. **Ghosh Suranjana**

   Fractional Revivals in Quantum Systems and their Applications. (2007) Nirma University.

8. **Patel Bhavesh G.**

   Spectroscopic studies and characterization of laser produced plasmas. (2007) Mohanlal Shukhadia University, Udaipur.

9. **Ribu Cherian**

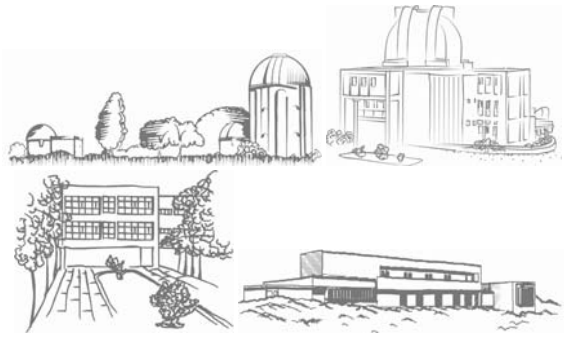
   Aerosol characteristics over continental India and surrounding oceanic regions. (2007) Cochin University of Science and Technology, Cochin.

10. **Roy Utpal**

    Solitons in non-linear media and their coherent control. (2007) Nirma University.

11. **Murari Madhav Krishna**

    Component Specific Luminescence of Natural Minerals and their Application to the Dosimetry of Nature Radiation Environment. (2008) Mohanlal Shukhadia University, Udaipur.



Science

Astronomy & Astrophysics

The Astronomy and Astrophysics Division is engaged in research related to star formation, stellar evolution, explosive events like novae, highly obscured central regions of our galaxy and the nuclei of active galaxies. The sun and small bodies of solar system like comets and asteroids are also studied. New initiatives of the group are in the areas of search for Extra solar planets and X-ray astronomy.

Detection of Alumina Dust in V4332 Sgr from Spitzer Observations

Alumina plays a significant role in dust formation around oxygen-rich stars. Thermodynamic equilibrium calculations suggest it to be the earliest dust condensate in an oxygen rich environment. This prediction is yet to be confirmed through observations. A difficulty in the study of Alumina has been the uncertainty in identifying its spectral features. In particular there has been debate whether the bands at 11.3 and 13 μm in the spectra of several cool stars, arise from Alumina. Towards understanding the generic role of Alumina as a dust condensate, we studied the nova-like object V4332 Sgr. This object had a nova-like eruption in 1994 and a dust shell formed around it during the year 2000. Alumina formation was expected in this source since the object displayed 0

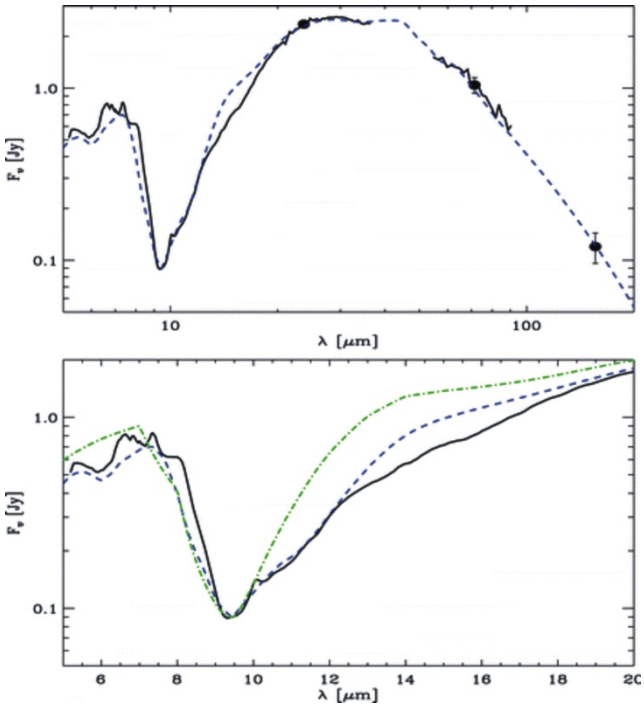


Figure 1 : The 5 to 160 micron spectral energy distribution (SED) for V4332 Sgr is shown at the top (bold line) fitted by the best radiative transfer model fit (dashed blue line) assuming a silicate to alumina composition for the dust in the ratio 0.65 to 0.35 .The bottom panel shows an expanded section of the SED which shows that a pure silicate model(green curve) yields a poor fit to the extended red wing of the data.

strong AlO bands in its near-infrared spectrum. AlO is expected to be a potentially important molecule leading to Alumina formation. We obtained Spitzer spectra and broad-band photometric observations of this source from Spitzer General Observer cycles 1 and 2 in 2005 and 2006. The spectra display an unusually broad absorption feature at 10 microns at the position associated with silicate rich dust. Through radiative transfer modeling using the DUSTY code, it was demonstrated that this broad feature cannot be explained by silicates only but requires the inclusion of Alumina as a dust condensate. In particular, it was seen that the signatures of amorphous Alumina are a broadening of the red ward wing of the 10 micron silicate feature and the creation of a discernible bump at 11-11.5 micron on the shoulder of the silicate feature (Figure 1). Current studies aim at the use of multi-epoch observations on the changes in the silicate and Alumina features and, correlating their evolution with theoretical dust condensation models.

This work is being done in collaboration with K.A. Misselt and K.Y.L Su of the Steward Observatory, University of Arizona, Tucson, USA

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

Infrared Spectroscopic Study of AGB and Post-AGB Stars

Mass loss processes play a vital role in the astrophysical evolution of intermediate mass stars. As a continuing program regular systematic observations of a selected sample of AGB/post-AGB stars that exhibits variability over time scales of a few weeks to months are being made. The variability is attributed to changes in the rate of mass loss. Depending upon the effective temperature of the star evolving from AGB to post-AGB phase, spectral line variability among Hydrogen Brackett series lines of some stars was seen and, in some others the CO first and second overtone bands indicated variability. Efforts on the synthetic profile modeling of the observed spectra, to elucidate the evolutionary nature of these stars, are underway. Spectral energy distributions reconstructed from archival data in the near, mid and far-infrared regions are being modeled for Polycyclic Aromatic Hydrocarbons (PAH) and other molecular/dust features.

(V.Venkataraman and B.G.Anandarao)

Multi-wavelength Studies on Massive Star-forming Regions

Massive stars have a substantial influence on the evolution of the Galaxy, because they are the main source of energetic radiations and of heavy elements. The formation mechanism and early evolution of massive stars are not well understood. These are situated far away and hence suffer a large extinction. This along with short formation time scales make it difficult to study these star forming regions. In order to minimize the extinction, these regions are best studied in the near, mid and far-infrared wave-lengths. Such a multi-wavelength investigation is important in understanding the stellar content and ages of massive star forming regions. With this aim, a study of selected massive star forming regions using the archival SPITZER data, was initiated. In addition, observations in JHK photometric bands at Mt Abu were initiated. These are being coupled with the X-ray observations (from archives of CHANDRA) to correlate with evolutionary stages of massive protostars. Such a correlative study is expected to lead to an understanding of the physical conditions around massive protostars and help identify the most massive members in a cluster.

This work is being done in collaboration with. M.S.N Kumar of University of Porto, Porto, Portugal.

(Lokesh Dewangan, Santosh Vadawale and B.G. Anandarao)

Near Infrared Observations of Mutual Events of the Satellites of Uranus

Since 2007 planet Uranus has been passing through one of the nodes in the equatorial plane of its orbit. This passage occurs once in 42 years and during this time the satellites of Uranus eclipse and occult one another, when they align with respect to the Sun and the Earth respectively. The duration of these mutual events, the drop in signal level observed along with the determination of the midtime of the events will help in constraining the relative longitude and inclination of the five main Uranian satellites which are otherwise poorly determined.

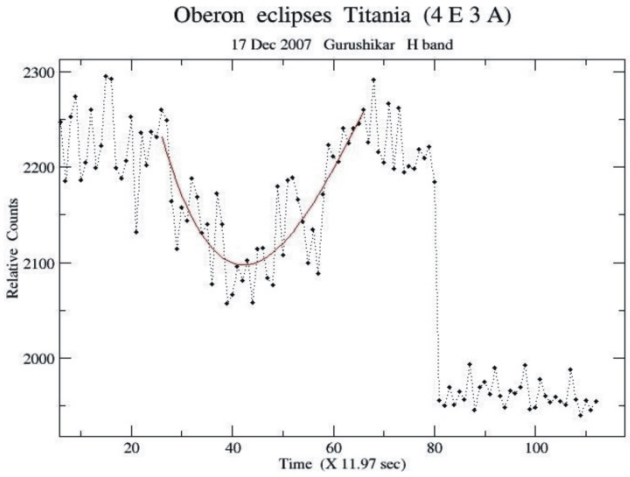


Figure 2 : Oberon, a satellite of planet Uranus eclipses another satellite Titania during a rare mutual event observed from Mt Abu on 17 December 2007. The combined light from the two satellites in the IR H band at 1.65 microns is found to decrease by more than half during the peak eclipse. A cubic fit to the eclipsed portion is also shown.

Compared to satellites of Jupiter or Saturn, the satellites in the Uranus system are fainter and their IR magnitudes ranges from 12.5 to 15. As their projected angular distance from Uranus is in the range of 7-10 arcsec, monitoring of

these objects in the visible region, in the vicinity of the bright planet is an observational challenge. However, observations in the near-infrared (NIR) provide an improved contrast as the planet is substantially darker in NIR by several magnitudes.

During the winter of 2007, many mutual events were successfully observed at Mt. Abu observatory in the J and H NIR bands using the NICMOS IR camera. Figure 2 shows the eclipse of satellite Titania by satellite Oberon in the H band at Gurushikar. The cumulative dip during peak eclipse is higher than the value derived from geometric considerations and suggests a variation of albedo of the eclipsed surface of Titania.

(T. Chandrasekhar, Vishal Joshi, R.R. Shah, J. K. Jain and G. S. Raj Purohit)

Variability in Blazars

To understand the energy generation mechanism and the structure of AGNs and the blazers, a set of bright blazars are being monitored from Mt Abu Infrared Observatory. Objects, 3C66a, 3C279, 3C454.3, Mrk421, Mrk 501, BL Lac, OJ287, 1ES2344, PKS0716, H1426 W Com were observed in the near infrared (using NICMOS-3) and in the optical regions (using polarimeter and CCD). Of these, Mrk 421, Mrk 501, 1ES2344, H1426 and 3C66a are gamma-ray loud sources and emit substantial radiation in TeV energy regime. The low energy component of the spectral energy distribution (SED) of blazars has been attributed to synchrotron emission from the relativistic electrons. The origin of the higher energy component, extending from X-ray to high energy gamma-rays however is poorly understood. Further such long term multi-wavelength monitoring of the blazars for variability is the key to elucidate the geometry of the jets and the associated physical processes.

Our observations indicate that PKS0716 was bright (~12.5 mag in R) during Jan 2007, fading to 13.1 mag in March and re-brightening to 12.6 mag in November, only to fade to 13.7 towards the end of 2007. Similar trend was seen in B, V and I bands. The re-brightening in November is perhaps in correspondence with the strong Gamma-ray detection of the source by AGILE spacecraft in September 2007. The source also showed outburst in radio frequency region during the optical brightening phase in November. Blazar 3c279 was also bright in Jan 2007, fading to 16.0 in May and then brightening 2.5 times up to about 15.0 in June 2007.

(K. S. Baliyan, U. C. Joshi and S. Ganesh)

Convection Zones and Internal Structure of White Dwarfs:- The Whole Earth Telescope

An understanding of the stellar interiors and their atmospheres is of great interest. Stellar mass, effective temperatures, carbon/oxygen ratio etc of white dwarfs can be estimated using their linear pulsations and seismological models. Hydrogen and Helium atmosphere around white dwarfs at about 12000°K and 25000°K respectively exhibit pulsations of periods between 100 to 1100 seconds. The fractional amplitudes changes range from a few tenths of a percent to about 30%. These pulsations manifest themselves via the variation of their light curves. In addition, some cooler white dwarfs with large amplitude fluctuations also show non-linearity in their pulsations, caused possibly through the interaction with the outer convection zone. This study helps in improving the knowledge of the convection zone depth which is a significant source of error in stellar models. However, the study requires continuous long duration light curves which are possible only when a large number of observatories on earth monitor a single target, providing for a Whole Earth telescope (WET). During November 8-14, 2007, we participated in a campaign on the white dwarf G-38-29. During this period, this source was observed for up to 6 hrs every night. Fractional amplitudes were obtained and plotted as a function of time to get light curves. The Fourier transform of the light curves provided the periods of pulsation. By combining light curves from all participating observatories, over 30 periods were inferred. These are the normal modes of oscillations described by spherical harmonics. The physical stellar models can now be used fit to these pulsation periods, amplitudes and phase to understand stellar structure and convection zone depths.

This work was done in collaboration with the WET team comprising about 50 astronomers from over 30 countries.

(K. S. Baliyan and H. O. Vats)

Dependence of Initiation of Coronal Mass Ejections on Solar Flare Plasma Temperature

The complex relationship between solar flares and coronal mass ejections (CMEs) has been studied intensively, but is as yet, poorly understood. Although it has long been known that the two phenomena often occur in conjunction, the relationship is not one-to-one. The relationship between initial velocity of the CMEs (observed by LASCO - C2 and C3 coronagraphs onboard SOHO) and the temperature of the plasma of associated X-ray flare (based on 26 flare events observed by "Solar X-ray Spectrometer (SOXS)" mission) was investigated. Initiation of the CME and soft X-ray flare in the lower corona around 1.1 R_s altitude from the disk center was used to obtain the initial velocity of the CME at this altitude using a best-fit of the C2 and C3 observations. These were compared with the onset time of the flare in 4.1-10 keV region observed by the SOXS-CZT detector. It was seen that in 16 events the CME preceded the flare, and in 10 events the flare occurred before the CME. Our measurements of the X-ray flare plasma temperature and photon index below and above the break energy

along with the use of multi-thermal and broken power-law functions, show that the initial velocity of CMEs increases with, temperature (R=0.82) of the flare plasma (Figure 3) and the photon index below break energy (R=0.64) and, it

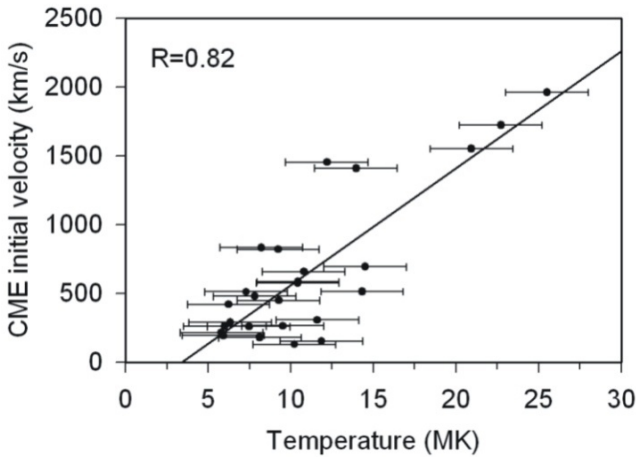


Figure 3 : The initial velocity of the CMEs as a function of the flare temperature during evolution. The CZT detector restricts temperature measurements to an accuracy of +/- 2.3 million Kelvin (MK)as indicated by the error bars.

reduces asymptotically with photon index above break energy. These results suggest that the heating of coronal plasma is important in releasing the CME from the reconnection region, where the flare also occurs.

(Rajmal Jain and Malini Aggarwal)

Detection of 1.38 year Periodicity and 27 day Solar Rotation in X-ray Corona

The Si detector on SOXS provides full disk integrated X-ray emission in the 4-25, 6-7, 7-10 and 10-20 keV energy bands while the CZT detector operates in the 6-7, 7-10, 10-20, 20-30 and 30-56 keV energy bands. The X-ray emission in a given energy band for a given day of observations was reduced to a "Daily X-ray Index (DXI)" as a proxy to measure the intensity of the corona. The time series of the proxy DXI during the declining phase of solar cycle 23, (from 13 November 2003 to 30 April 2008) was Fourier analyzed to obtain a noise-free power spectrum. Periodicities of 1.38 year and 27 and 13.5 days were detected. The 1.38 years periodicity in the was seen in the high energ bands only. The 27 and 13.5 days periodicities were observed in both the soft and hard X-ray bands. A 1.38 year periodicity in high energy bands suggests that the lower corona is connected with the base of the convection envelope and represents changes in the rotation of the Sun. Periodicities of 26.6 and 13.5 days are related to 180^0 oppositely directed active longitudes visible in soft and hard X-ray bands.

This work was done in collaboration with Babita Chandel, Rajni Devi and A.K. Gwal of Dept of Physics, Barkatullah University, Bhopal

(Rajmal Jain and Malini Aggarwal)

Cross-Calibrations among SOXS, GOES and RHESSI Missions

A comparative study between the magnitude of flares observed by the SOXS experiment onboard GSAT-2 spacecraft and the Geostationary. Operational. Environmental.Satellites. (GOES) satellite was undertaken. Both satellites operate in geosynchronous orbits. The cross correlation between X-ray magnitude of flares observed by the Si detector of SOXS in the 7-10 keV range and by GOES ion detector in the 1.6-12.4 keV range was excellent (R=0.92) (Figure 4). The correlation would improve further,

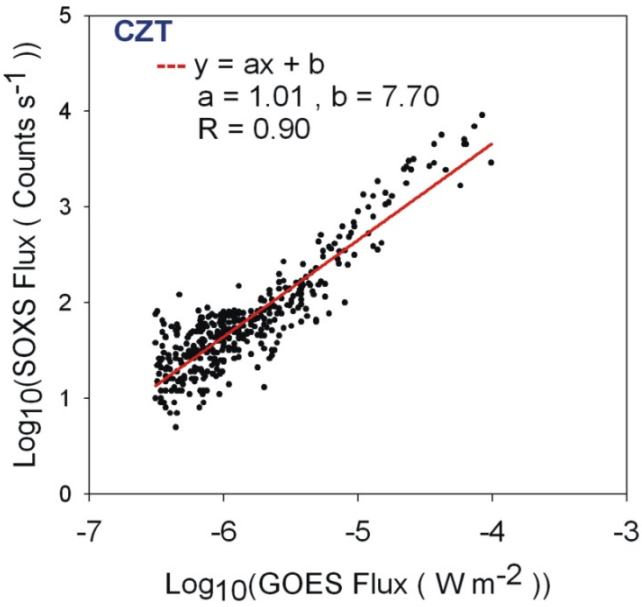


Figure 4 : Comparative study of flare magnitudes observed by SOXS Si detector in 7 -10 kev and GOES ion detector in 1.6 -12.4 kev shows excellent correlation(R= 0.92)

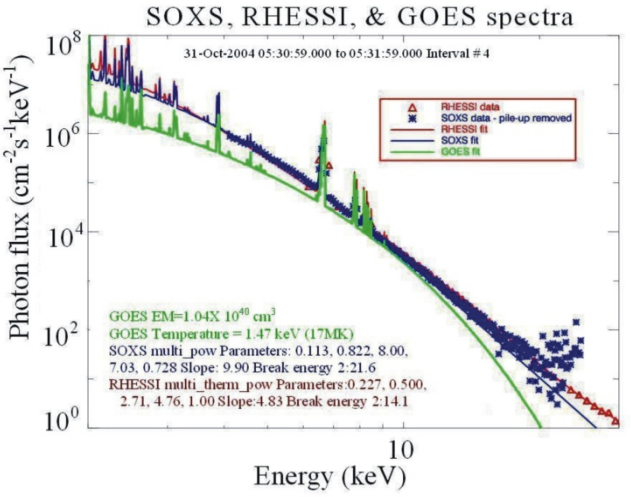


Figure 5 : Spectra of solar flare event obtained by SOXS, and RHESSI are in good agreement throughout the energy range. The GOES spectrum deviates from these at lower and higher energies.

if the temporal resolution and energy bands of both instruments were the same. The SOXS has observational limits that restrict its use for the flares below B 2.0, while GOES is limited in terms of its temporal resolution relative

to SOXS. The spectral comparison among SOXS, GOES and RHESSI (Ramaty High Energy Solar Spectroscopic Imager) satellites is presented in Figure 5. The SOXS and RHESSI spectral data sets are agreement over the energy range (1 kev-25 kev), while the GOES spectrum lies below SOXS and RHESSI spectra at lower as well as at higher energies. The SOXS, RHESSI flux ratio varies between 0.8 and 1.0, and the flux ratios of SOXS/GOES and RHESSI/GOES also follow similar trends and suggest that there is no discrepancy in detector response validation. However, the energy range of the photons contributing most to the GOES soft X-ray is typically about 4 keV in both the channels at higher temperatures while the SOXS and RHESSI X-ray response ranges are higher than that of GOES**.** This explains why GOES spectra remains low at lower and higher energies relative to SOXS and RHESSI spectra.

(Rajmal Jain, Malini Aggarwal and Arvind Rajpurohit)

Microflares as Possible Sources for Coronal Heating

Flares on GOES intensity class ≤ C1.0 are defined as microflares. It is suggested that the main source of energy for heating the corona is the magnetic field that dominates the corona. Magnetic reconnection is probably the most important mechanism for releasing magnetic energy and may, therefore, be important for coronal heating or micro-flaring. Microflares are amongst the potential candidates for coronal heating. A study of 27 microflares observed by the SOXS mission during July 2003 to August 2006 show a Fe-line feature peaking around 6.7 keV. This suggests the presence of coronal plasma at a temperature ≥9MK. On the other hand, the spectra of microflares described by a hybrid of thermal and nonthermal emission, further supports microflares as a possible source of coronal heating. The presence of the Fe line feature in the micro-flares implies that the energy released by them is adequate to heat the active corona. The temporal evolution of a recently observed microflare on 25 March 2008 shows a higher flux in 6-8 keV energy band and indicates that this microflare is a Fe-rich flare.

This work was done in collaboration with Meera Gupta (Dept of Physics,Govt Girl's college, Durg) and A.P.Mishra (Dept of Physics, A.P.S.University, Rewa).

(Rajmal Jain and Malini Aggarwal)

Rotation of Sun and its Atmosphere

We investigated the rotational features of the solar corona as an ongoing observational programme on solar radio emissions with time. The peculiarity of coronal rotation period peaking at ~ 80^0 latitude was explained as possibly due to the fact that the streamers rooted at lower latitudes may be seen in the polar region as these rotate in front or behind the disk. Since the streamers have higher rotation rate (i.e. lower rotation period) appropriate to the latitude of their bases. When these streamers are seen near the poles, they appear to have a higher rotation rate. Radio measurements of coronal rotation are close to optical measurements (specially at lower latitudes of 9^0 and 24^0) during 1986 – 1991. Thereafter the two start diverging the radio values reach a minimum during 1998 and differ in excess of 2 days from the optical measurements even at low latitude. Given that the radio measurements are based on the disk-integrated flux of the Sun, these are dominated by equatorial rotation. Thus it is reasonable that optical measurements of low latitude are closer to the radio measurements.

The simultaneous radio flux investigations indicate that the sidereal rotation period at the highest frequency (2800 MHz), which originates from the lower corona at around 6×10^4 km, is 24.1 days. The sidereal rotation period decreases with height to 23.7 days at 405 MHz, that originates at 13×10^4 km. A 2% variation of the sidereal coronal rotation in this height range presents an interesting new complexity for the solar coronal rotation. The coronal rotation rate obtained by radio method is faster than that by the optical method in the equatorial region by about 7%.

This work is being done in collaboration with Mehul Mehta (V.P.Science College, Vallabh Vidyanagar, Gujarat) and Satish Chandra (SHD College, Sitapur, UP.)

(Hari Om Vats)

Hard X-ray Pulsations from a Rotating Magnetized White Dwarf, AE Aquarii

White dwarfs and pulsars represent distinct classes of compact objects that are born in the wake of stellar death. A white dwarf forms when a star similar in mass to our Sun runs out of its nuclear fuel. As the outer layers puff off into space, the core gravitationally contracts into a sphere about the size of Earth, but with the mass of our Sun. The white dwarf starts off scorching hot from the star's residual heat. But with nothing to sustain the nuclear reactions, it slowly cools over billions of years, eventually fadies to near invisibility. Some of the white dwarfs spin rapidly and have magnetic fields millions of times stronger than the Earth's field. Such strongly magnetized white dwarfs have a potential to serve as new particle acceleration sites for cosmic-rays. Since white dwarfs are common objects, large in number, they should become quiet accelerators giving important contributions to low-energy cosmic-ray fluxes.

AE Aquarii is a fast rotating white dwarf in a binary system with a normal companion star. The magnetic field of this object is in the range of 10^5-10^6 Gauss and the spin period is about 33 seconds. AE Aquarii was observed with the Japanese X-ray observatory SUZAKU at two different epochs in 2005 October 30 and 2006 October 25, for 53 and 43 kilosecs respectively. The X-ray data from these two observations indicated spiky pulsations (~ 33 seconds), akin

to neutron star pulsars, in the hard X-ray band. This was in addition to the well-documented thermal modulation in

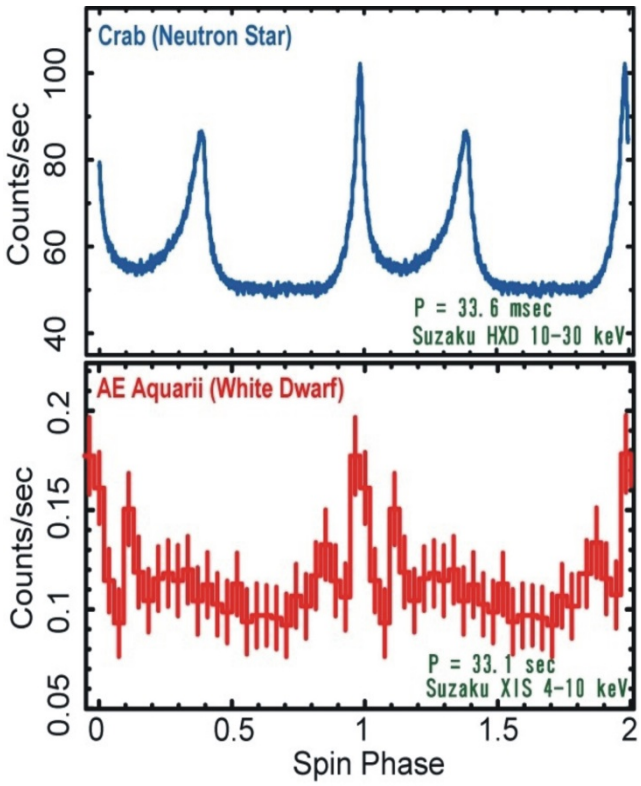


Figure 6 : The 33.6 millisec and 33.1 sec pulse profiles of the Crab pulsar and white dwarf AE Aquarii are shown at the top and bottom panels respectively.The pulse profiles were both observed in X-ray by the Japanese satellite Suzaku.

the soft X-ray band. Phase averaged 1.5-10 keV spectra can be reproduced by two thermal components with temperatures of 2.9 keV and 0.53 keV, whereas the 12-25 keV data show a significant excess above the extrapolated model. This excess can be explained by either a power-law model or a third thermal component with a temperature of about 54 keV. At a source distance of 102 pc, the 4-30 keV luminosities of the thermal and the additional components become 1.7 and 5.3 X 10 ^{29} erg s^{-1}, respectively (Figure 6).

This work was carried out in collaboration with T.Dotani and 9 other colleagues from the Institute of Space and Astronautical Sciences (ISAS), Japan

(Sachindra Naik)

Anomalous X-ray Pulsar CXOU~J164710.2 -455216 Observations with Suzaku

The Anomalous X-ray pulsars (AXPs) are a small group of X-ray pulsars that show common properties such as, (i) their presence within 1 degree of the Galactic plane, (ii) their pulse period in a narrow range of 5-12 s unlike the radio pulsars and accreting X-ray pulsars, (iii) a larger and –nearly steady spin-down or braking, (in contrast to most accretion powered pulsars which show spin ups and downs), (iv) similar spectrum with soft component characterized by a blackbody model at temperature below 1 keV, (with additional harder component in some cases), and (v) relatively high X-ray luminosity (~10^{34} – 10^{36} erg s^{-1}) that cannot be obtained from the loss of rotational energy of a neutron star alone.

These objects are believed to be young (10^3 – 10^5 yrs) and some of them are associated with supernova remnants (SNRs). The AXPs are considered to be the neutron stars with the strongest known magnetic field (10^{14} - 10^{15} G). However, a direct experimental confirmation of the presence of such high magnetic field strengths is still needed. The source of energy for the radiative emission in AXPs is described by the Magnetar model, in which the decay of an ultra - strong magnetic field powers the high-luminosity bursts and also a substantial fraction of the persistence X-ray emission. The competing model for the mechanism of powering the X-ray emission in AXPs is that the AXPs are neutron stars surrounded by fossil disks acquired during supernova collapse or during a common-envelope interaction.

Recently discovered AXP CXOU~J164710.2-455216 is located in the young, massive Galactic star cluster Westerlund 1. Following the detection of an intense (~10^{39} erg s^{-1}) and short (20 ms) burst from the AXP, it could be observed with various X-ray observatories. Suzaku performed a Target of Opportunity (TOO) observation of the object on 2006 September 23-24 for a net exposure of 38.8 kilosecs. Pulsations were clearly detected in the XIS light curves with a pulse period of 10.6 s. The XIS pulse profile was non-sinusoidal and had 3 peaks of different amplitudes with RMS fractional amplitude of ~11% in 0.2--6.0 keV energy band. The 1--10 keV XIS spectra could be fitted by a model comprising two blackbody components with temperatures of 0.61 ± 0.01 keV and 1.22 ± 0.06 keV and the absorption column density of 1.73±0.03 ×10^{22} atoms cm^{-2}. Pulse phase resolved spectroscopy indicated that the flux of the soft blackbody component comprised three narrow peaks, whereas the flux of the other component had a single peak over the pulse period of the AXP. The blackbody radii ranged between 2.2--2.7 km and 0.28--0.38 km (assuming the source distance to be 5 kpc) over pulse phases for the soft and hard components, respectively.

This work was carried out in collaboration with T. Dotani and 11 other colleagues from Institute of Space and Astronautical Sciences (ISAS) Japan.

(Sachindra Naik)

1-D Solar Maps with the Prototype Brazilian Decimetric Array

The prototype Brazilian Decimetric Array (PBDA) consists of 5 antennas operating frequency range of 1.2 – 1.7 GHz. This has a temporal resolution of 100ms on consist of mesh type dishes with an f/d ratio of 0.42 and alt–azimuth mounts with a tracking capability of 340^o in azimuth and 0^o

– 90° in elevation. The pointing accuracy is < 3 arc minutes with the sensitivity being ~0.8 SFU (1 SFU = 10000 Jy) for solar observations and ~13 Jy/beam for non-solar observations. Analysis of PDBA data requires custo-mized software and a computer program to reduce PBDA data to make 1-D solar maps this are being developed.

This work is being carried out in collaboration with H.S. Sawant and Colleagues at Instituto. Nacional Pesquisas Espaciais (INPE). Brazil.

(P. Janardhan)

Prototype Brazilian Decimetric Array Calibration using GPS Signals

Observations of signals from GPS (Global Positioning System) satellites to be used as calibrator sources for the Brazilian Decimetric Array (BDA) were proposed as a possible alternative for the use of known celestial radio sources from presently available catalogs. The principle reason for seeking alternatives is the lack of bright sources with fluxes ~ 1000 Jy (or greater), as required for the calibration of solar interferometer data, based on observations of celestial sources.

This difficulty is roughly overcome in observations with large telescopes like the Giant Metrewave Radio Telescope (GMRT) or Very Large.Array (VLA), since the sensitivity is enough for observing weak radio sources. While the Sun can be observed with these large Telescopes using appropriate attenuation. The effect of the attenuators on the signals can be calibrated through the use of known noise sources at the first stage of the antenna receivers. However, the sensitivity of the prototype of the BDA is low (due to the smaller number of antennas in the array and a smaller diameter of 4 m) Further as the system operates on single polarization it implies that half of the power is lost. This makes BDA suitable for sources > ~ 1000 Jy. Thus leaving only a small number of possible celestial calibrators are available in the BDA sky.

On the other hand, the GPS satellites are powerful sources (the response of the telescope in GPS observations is of the order of the response in Solar observations) with a well defined source of radiation. They are in the far field and can be considered as point sources for the full range of BDA baselines (even after the whole array is set up). The position of the satellites in the sky is also well known from their orbital parameters. These properties suggest that GPS satellites might be good sources for calibrating solar observations. A study was initiated to attempt to obtain antenna-based solutions for the calibration of BDA complex visibility data from observations of GPS satellites.

This work was carried out in collaboration with H.S. Sawant and colleagues at INPE, Brazil.

(P. Janardhan)

Indian X-ray Polarization Explorer

Polarization is an important property of radiation from astrophysical sources and carries unique information regarding the emission mechanism, physical condition and emission geometry at the origin. Though the importance of polarization measurements of X-rays was realized from the early stages of X-ray astronomy, these have been mostly unexplored. So far, there is only one accepted measurement of polarization from an astrophysical source (the Crabnebula). This was carried out in 1970s by a polarimeter onboard satellite OSO-8. No X-ray polarimeter has flown into space since then.

X-ray polarization measurements inform on the behavior of matter and radiation under extreme magnetic and gravitational fields. Further, such measurements can verify some of the key predictions of fundamental physics (e.g. QED, general relativity, quantum gravity), that are inaccessible from other methods. Presently several efforts (involving cumbersome reanalysis, through simulations and lengthy computations) are underway to recover polarimetric information from the existing data obtained by detectors that were not optimized for polarimetric observations.

Recently the Indian Space Research Organisation has announced the availability of a small satellite for astronomy. PRL and the Raman Research Institute, Bangalore (RRI) have jointly proposed an experiment to measure the X-ray polarization using a pragmatic approach to develop the first generation polarimeter. It is proposed to design the polarimeter based on Thomson scattering. This payload will have a collecting area of ~ 600 cm^2 and will be sensitive in the energy range of 8 – 30 keV. The bright Galactic X-ray sources will be the prime targets. The expected sensitivity is ~2% MDP (Minimum Detectable Polarization) at 3σ level from a one Crab source and for a ~1 Ms exposure. The proposal has been favorably reviewed and detailed technical design to test various feasibility aspects are underway. In parallel, experimental studies and a laboratory model of the experiment is underway for completion in a year.

(Santosh V.Vadawale, Sachindra Naik and N.M. Ashok)

PARAS: PRL Advanced Radial-velocity All-sky Search

There is a scientific need for high-resolution spectrographs with high efficiency and wavelength stability for precise radial velocity measurements (3 to 5m/s) of stars and for other astrophysical studies like stellar pulsations etc. Recent success of such spectrometers coupled with small telescopes (1-2 meter class) establishes their viability and utility. For instance, numerous extra-solar planets have been discovered using the ESO's CORALIE Echelle spectrograph coupled with a 1.2 m telescope, and the

ELODIE/SOPHIE (Spectrograph for Observations of Astro-seismological Phenomena and Extra solar planets.) spectro-graph coupled with a 1.9 m telescope. The upcoming HERMES (High Efficiency and Resolution Mercator Echelle spectrograph) with a 1.2 m telescope at La Palma Obervatory, Spain will focus on stellar pulsations and circumstellar disk studies etc.

PARAS is designed and optimized to be a fiber-fed, high resolution (R=70,000), seeing limited (1.9 arcsecs) Echelle Spectrograph for use with the 1.2 m telescope at Mt. Abu. The science goals of PARAS are, (a) Detecting low-mass planets around late G and K dwarfs, (b) efficient and timely follow up Radial Velocity observations of transit candidates from ground and space-based transit surveys, (c) Radial Velocity searches for massive planets in intermediate age clusters and (d) search for planets around G, K Giants.

We estimate the spectrograph to be >30% efficient from the slit to the CCD detector, and up to 15% efficient including sky, telescope, fiber-fed optics etc. Anticipated signal to noise ratio (S/N) ratio is 70 for a 10 magnitude star and for an integration time of 40 minutes. We aim to achieve 5 m/s to 3 m/s radial velocity accuracies on such a star using the simultaneous Th-Ar referencing method. Since thermal stability is absolutely necessary to achieve < 5m/s RV accuracies, the whole spectrograph will be in a thermally isolated room at 28°C +/- 0.01°C. The Optical designing for PARAS has been completed and the the fabrication in underway. The first light is anticipated by mid 2009.

(Abhijit Chakraborty, B.G.Anandarao and N.M.Ashok)

Planetary and Geosciences

The activities of Planetary and Geosciences group aims to understand the Origin and evolution of the Solar system, (with emphasis on Earth), using a variety of chemical, isotopic and luminescence techniques. The research centres on a variety of topics that range from meteorites to understand the origin and early stage of evolution of the Solar system to the processes on Earth, particularly in understanding its internal (mantle and lithosphere) and external reservoirs (atmosphere, hydrosphere and biosphere) and interaction between them. These studies enable an understanding of the role of climate, tectonics, bio geochemical cycles in sculpting the mountains, landforms, oceans chemistry and the dynamics of the atmosphere.

Correlated Presence of ^{60}Fe and ^{26}Al in Early Solar System.

Short-lived nuclide ^{60}Fe (half-life=1.5Ma) is unique product of stellar nucleosynthesis. A robust value for the initial abundance of ^{60}Fe in the solar system allows us to infer its possible stellar source and contribution from this source to the inventory of the other co-injected short-lived nuclides. Absence of Fe-rich phases in meteoritic Ca-Al-Inclusions (CAIs, considered as the first solids to form in the solar nebula), led to studies on Fe-rich sulfides and silicates in Unequilibriated Ordinary Chondrites (UOC) to infer initial abundance of ^{60}Fe in the solar system. We have initiated a study of Fe-Ni isotope systematics in a set of UOC chondrules whose formation time (relative to CAIs) was inferred using the records of the short-lived nuclide ^{26}Al (half-life=0.73Ma). Five chondrules from two unequilibrated ordinary chondrites, Semarkona and LEW 86314 were studied for their Fe-Ni isotope systematics using a Cameca ims-4f ion micro-probe. Data from multiple analyses of the same spot were combined, (as long as the Fe/Ni ratios were nearly the same), to improve precision of the measured isotope ratios. Four of the chondrules yielded initial ^{60}Fe/^{56}Fe ratios ranging from ~5×10^{-7} to 3.8×10^{-7}. The corresponding range of initial ^{26}Al/^{27}Al is ~1.6×10^{-5} - 1.1×10^{-5}. The fifth chondrule, hosting the lowest initial ^{26}Al/^{27}Al [$(5.5\pm0.32)\times10^{-6}$], yielded an upper limit of 3×10^{-7} for initial ^{60}Fe/^{56}Fe. Our data suggest a good correlation between the initial ^{60}Fe/^{56}Fe and initial ^{26}Al/^{27}Al. If we consider the time of formation of chondrules, relative to CAIs, based on their ^{26}Al record and the canonical Solar system (CAI) initial ^{26}Al/^{27}Al value of 5×10^{-5}. This correlation can be explained, if we consider simultaneous injection of both these nuclides from a common stellar source. We infer a solar system initial ^{60}Fe/^{56}Fe value of ~8×10^{-7} that suggests a supernova origin for ^{60}Fe. Our results question a recent proposal that injection of ^{26}Al from

a massive star preceded that of ^{60}Fe (from the same star) by more than a million years.

(R. Mishra and J. N. Goswami)

Duration of Chondrule Formation and Parent Body Thermal Metamorphis

Fossil records of now-extinct short-lived nuclide ^{26}Al were analyzed in more than two dozen chondrules from nine unequilibrated ordinary chondrites (UOCs) of low petrographic grades to infer their time of formation. These were Semarkona (3.0) LEW86134 (3.0), QUE97008 (3.05), Bishunpur (3.1), Adrar-003, (3.01), Y791324 (3.1), LEW86018 (3.1), ALHA77176 (3.2) and ALHA76004 (3.3), belonging to the L and LL group to infer their time of formation (Figure 7). These meteorites did not experience temperature in excess of 350^{0}C for more than a few million years in their

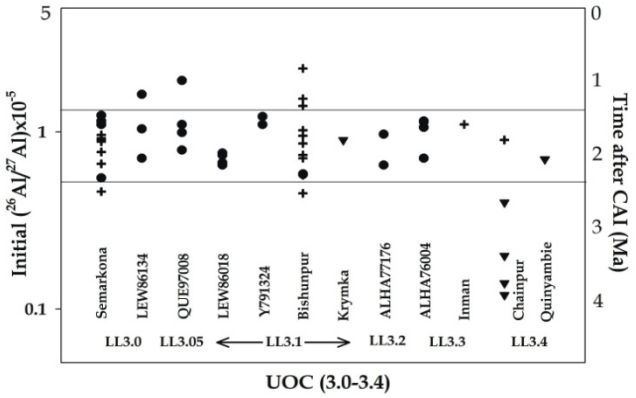


Figure 7 : Distribution of initial $^{26}Al/^{27}Al$ values for UOC chondrules analyzed alongwith those reported in literature. The inverted solid triangles represent upper limit estimates for chondrules from Krymka, Chainpur and Quinyambie.

parent bodies and thus the chondrules in them are expected to preserve their pristine Al-Mg isotope records. The data obtained by us, firmly establishes a short duration of < 1 million years for the major episode of UOC chondrule formation. Nebular processes responsible for chondrule formation started ~1 Ma after formation of CAIs and effectively stopped within one and a half million years in the inner region of the asteroidal belt. Modeling of thermal evolution of chondritic parent bodies suggest that the longer duration of UOC chondrule formation inferred in some of the earlier studies in UOCs of petrographic grades >3.3 and, rare occurrence of chondrules with low initial $^{26}Al/^{27}Al$ ratio in UOCs of lower petrographic grades could be attributed to thermal metamorphism experienced by chondrules in UOC parent bodies during their residence at shallow depth (>2km) as an independent entity prior to their incorpo-ration into host meteorites.

(N. G. Rudraswami and J. N. Goswami)

In-situ Search of Presolar Grains from Tagish Lake Meteorite

Search for presolar silicates in Tagish Lake meteorite was carried out using nano-SIMS (Secondary Ion Mass Spectrometer) at Washington University, St. Louis by raster imaging of ^{16}O, ^{17}O and ^{18}O, ^{28}Si and $^{27}Al^{16}O$. Data reduction of the total analyzed area of 2800 μm^2 indicates absence of presolar silicate grains and a lower limit for the silicate grains abundance is placed at ~0.57 ppm. This, along with the earlier results from Tagish Lake meteorite (~4 ppm, area ~ 29250 μm^2) resets the abundance to 3.7 ppm for presolar silicate grains in it. Such a low abundance of presolar silicates in this meteorite is attributed to aqueous alteration.

(K. K. Marhas)

Designing Automatic Imaging System for Secondary Ion Mass Spectrometer

For automatic scanning of a sample mount (2.5 cm) by the ion probe and to image it for selected isotopes, a micro controller based XY-stage is being designed for attachment with the ion probe. Towards this, a test module was made with two 2-phase stepper motors (to move the XY-stage) interfaced to a computer via a microprocessor. The stepper motors could be driven stepwise by microcontroller (AT89c51) as per the user defined parameters. The AT89c51 microcontroller, programmed in assembly language was interfaced with the PC using Turbo-C or Visual Basic. Additionally, a simulator has been designed to control the primary beam of SIMS to avoid sputtering of the sample during the movement of stage. This minimizes the sample usage per analysis. The simulator has also been interfaced to the microcontroller AT89c51 and can be controlled by a software.

(Dipak Panda and K. K. Marhas)

Solar Gases in Kavarpura Iron Meteorite

Two adjacent pieces of Kavarpura, classified as IIE-Anomalous, were analyzed for noble gases by stepwise heating. Large amounts of He, Ne and Ar was seen and

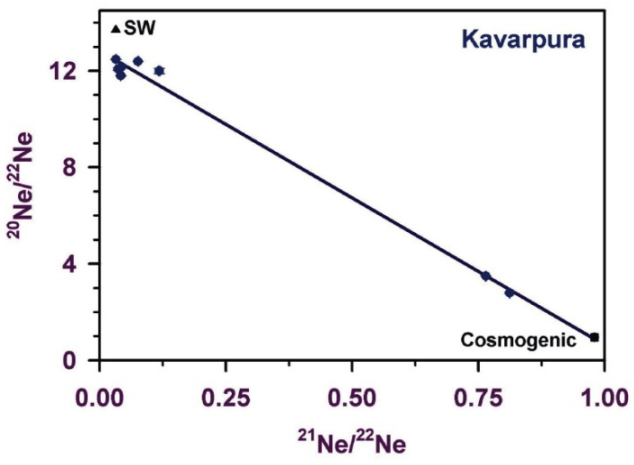


Figure 8 : Three isotope Ne plot (solid circles) for sample from Kavarpura meteorite. The solar wind and cosmogenic end members are also shown.

these were a mixture of trapped and cosmogenic components. Kr and Xe were close to blank levels possibly due to small sample amounts. Highest measured $^{20}Ne/^{22}Ne$ ratio was 12.47 and in the three isotope plot, the data plotted along the Solar Wind (SW) cosmogenic mixing line (Figure 8). Using the cosmogenic He, Ne and Ar systematics of iron meteorites, the amounts trapped and cosmogenic gas in the two samples of Kavarpura were calculated as $^{20}Ne_t$: 209 and 58; $^{21}Ne_c$: 6.2 and 6.1 (in 10^{-8} ccSTP/g units). The elemental ratios in both the samples were indistinguishable with $(^4He/^{20}Ne)_t$ ~ 500; $(^{20}Ne/^{36}Ar)_t$ ~ 20; $(^3He/^{21}Ne)_c$ ~50 and $(^{38}Ar/^{21}Ne)_c$ ~ 4.3. The two adjacent samples differed by about a factor of four in their trapped SW component, suggesting that the trapped gases reside in some inhomogenously distributed inclusions and is not hosted in the metal phase. Peak release of SW gases at 800°C and cosmogenic gases at 1600°C (from the principal target phase, metal) suggest that the SW gases are not volume correlated in the metal; they are either hosted in a non- etallic phase with low thermal stability (if volume correlated) or the surface sited SW gases in this host phase were not disturbed during the formation of the parent body of Kavarpura.

(S. V. S. Murty and R. R. Mahajan)

Luminescence Studies on Meteorites

Although, the meteorite luminescence has been researched upon for decades, an important issue of anomalously low equivalent dose still remains unresolved. For eight chondritic meteorites (falls), conventional protocol yielded high temperature luminescence equivalent dose in the range 1000 Gy – 2000 Gy. This is about 100 times lower than the expected dose of ~10^5 Gy based on a CR exposure age of ~6 Ma and a dose rate of 0.044 Gy/year. Paleodose for Dhajala meteo-rite in different luminescence emission windows are 330±17 Gy (UV), 980±28 Gy (Blue) and 1080±39 Gy (Red) and isothermal luminescence at 350°C in blue emission was 5 kGy. Red TL studies did not exhibit any HT peak. The cosmic ray flux was recalculated, taking into account attenuation of cosmic rays and luminescence efficiency of cosmic ray charged particles. The latter has so far been ignored. Thus for example, the pre-atmospheric size of Dhajala meteorite (43 cm) implies that the dose rate attenuated by 20%. Calculation of efficiency for High energy Heavy Charged Particle (HCP) was done using the results of luminescence efficiency of HCP for Al_2O_3:C. These gave a net interior CR dose rate of ~0.01 Gy/year and conjunctively these measurements imply an irradiation duration of ~$5x10^5$ years which though is 20 fold higher than the previous studies, still fall shoot of ^{21}Ne exposure ages by a factor of three. The reason for these are being investigated.

(R.H. Biswas, M.K. Murari, A.K.Singhvi)

Interplanetary Dust Particle Flux on Moon

Recent studies of individual mineral grains from lunar soils and lunar meteorites for N and Ar by laser heating have confirmed the existence of excess N with a $\delta^{15}N$ ~ +50. This suggests IDP's (Interplanetary Dust Particles) as the likely source of excess N. Moon is continuously bombarded by IDPs, rich in organics that have positive $\delta^{15}N$. On impact, the volatalised N gets deposited on the surface grains, similar to the parentless ^{40}Ar. As the excess N is acquired during the surface residence of grains (given by the cosmic ray exposure age of the sample), and the amount of parentless ^{40}Ar provided the surface exposure duration of the grains. It is thus possible to construct a trend of tempo-ral variation (if any) of excess N. This trend provides a means to assess the IDP flux on the Moon in the past. Using the available data on lunar soils and lunar meteorites with simultaneous N and Ar measurements, the excess N (and hence the IDP flux) as a function of time in the past was estimated. It was seen that in the time period spaning the last 1.8 Ga, the IDP flux increased by over an order of magnitude at 0.7 Ga.

(R. R. Mahajan and S. V. S. Murty)

Intramolecular Isotope Distribution of Ozone by Oxidation Reaction with Silver Metal

The intramolecular distribution of heavy isotopes in ozone is of interest for understanding the processes in the troposphere. Earlier spectroscopic works dealt only with ^{18}O and not ^{17}O. The oxidation reaction of ozone with silver was used as a new technique to determine the ^{17}O distribution. The isotope ratios $^{18}O/^{16}O$ and $^{17}O/^{16}O$ of silver oxide and ozone were used along with information on ^{18}O distribution in ozone in the literature to determine $r^{49} = [^{16}O^{16}O^{17}O]/[^{16}O^{17}O^{16}O]$. The r^{49} values increased with bulk ^{17}O-enrichment in ozone, analogous to the case of r^{50}, but are significantly higher than r^{50} values. The average difference between r^{49} and r^{50} values was 0.075 ± 0.026 (standard deviation). This small difference and corresponds to a large change in enrichment values of asymmetric and symmetric ozone species relative to a hypothetical ozone standard with a statistical isotope distribution. The difference reduces with the increase in bulk ozone enrichment. We also show that a similar difference is expected from the relative rate coefficient variation between these two species due to the zero point energy difference. Additionally, there is a negligible variation in r-values between ozone samples made by Tesla discharge and by UV photolysis of oxygen. For ozone samples with no enrichment, the symmetrical isotopomers have relatively more heavy isotopes than the asymmetrical ones. This is in contrast to the case of enriched ozone and is consistent with expectation from bond strength

considerations.

This work was done in collaboration with Dr. J. Savarino, Laboratoire de Glaciologie et Géophysique de l'Environnement, CNRS, Université Joseph Fourier-Grenoble, France

(S. K. Bhattacharya, Antra Pandey)

NO + O_3 : An Oxygen Isotope Perspective on the Reaction Dynamics and Implications for the transfer of the Ozone Isotopic Anomaly in the Atmosphere

Atmospheric nitrate shows a large oxygen isotopic anomaly, characterized by an excess enrichment of ^{17}O over ^{18}O, similar to the ozone molecule. With an aim to elucidate and quantify how nitrate inherits this unusual isotopic composition, the initial step of this transfer, namely the reaction NO + O_3, was examined. Available literature on the ozone intramolecular isotope distributions suggest that the central atom of the ozone is abstracted by NO with a probability of 8±5 % (±2σ) at room temperature. This result is qualitatively supported by dynamical reaction experiments, the non-Arrhenius behaviour of the kinetic rate of this reaction and the kinetic isotope fractionation factor. The transfer function of the isotopic anomaly of O_3 to NO_2 in the $\Delta^{17}O$ space ($\Delta^{17}O = \delta^{17}O - 0.52 \times \delta^{18}O$) described by the linear relation $\Delta^{17}O\ (NO_2) = \alpha\ \Delta^{17}O\ (O_3) + \beta$, with $\alpha = 1.17\pm0.04$ (±2σ) and $\beta = 6.7\pm1.0$ ‰ (±2σ) could be established. Such relationship can be incorporated in modeling work on the propagation of the ozone isotopic anomaly among oxygen-bearing species in the atmosphere and should help a better interpretation of the oxygen isotope anomaly of atmospheric nitrate in term of its formation reaction pathways.

This work was done in collaboration with Drs. J. Savarino, S. Morin, M. Baroni, M. Frey from Laboratoire de Glaciologie et Géophysique de l'Environnement, Université Joseph Fourier-Grenoble/CNRS, France and Dr. J.-F Doussin from Laboratoire Interuniversitaire des Systèmes Atmosphériques (LISA), Université Paris, France.

(S. K. Bhattacharya)

Mineral Dust in the Atmosphere over Mt. Abu Western India

At Mt Abu (24.6°N, 72.7°E, 1700 m above sea level), $PM_{2.5}$ and PM_{10} (particulate matter with an aerodynamic diameter of up to 2.5 or 10 µm) aerosol samples were collected on a weekly basis for one year. Mt Abu is in the semi-arid region of western India and experiences a large temporal variability in its atmospheric mineral dust. The fine mode ($PM_{2.5}$) aerosol mass varied in the range of 1.9 to 227 µg/m^3 and coarse mode ($PM_{2.5-10}$) in 0.6 to 102 µg/m^3 during May 2006 to June 2007. During the high-dust season (May-June), the mass fraction of fine mode particles (Av: 45±21%) was lower than the coarse fraction (Av: 54±21%). However, during winter months (Nov-Jan), the fractional contribution of both fine and coarse particles was nearly the same. Using Al concentration as a proxy for mineral dust, the aerosol abundance is almost uniform (74±16 and 68±12%) in coarse and fine fractions during summer months (May-June). In contrast, during winter time, contribution of dust in coarse mode (72±13%) is three-times higher than in the fine mode (24±9%). Such seasonal differences in abundance of dust in fine and coarse mode aerosols are attributed to the long-range transport associated with contribution from different sources.

(Ashwini Kumar and M.M. Sarin)

Chemical Properties of Aerosols over Bay of Bengal & Arabian Sea: A Comparative Study

The chemical composition of aerosols (collected during the period of March to May 2006) in the Marine Atmospheric Boundary Layer (MABL) of the Bay of Bengal (BoB) and the Arabian Sea (AS) were determined by analyzing the water soluble constituents (Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+},Cl^-, NO_3^- and SO_4^{2-}), crustal elements (Al, Fe, and Ca) and carbonaceous species (EC, OC). The total suspended particulates (TSP) ranged from 5.2 to 46.6 µg m^{-3} and 8.2 to 46.9 µg m^{-3}, in the BoB and AS respectively.

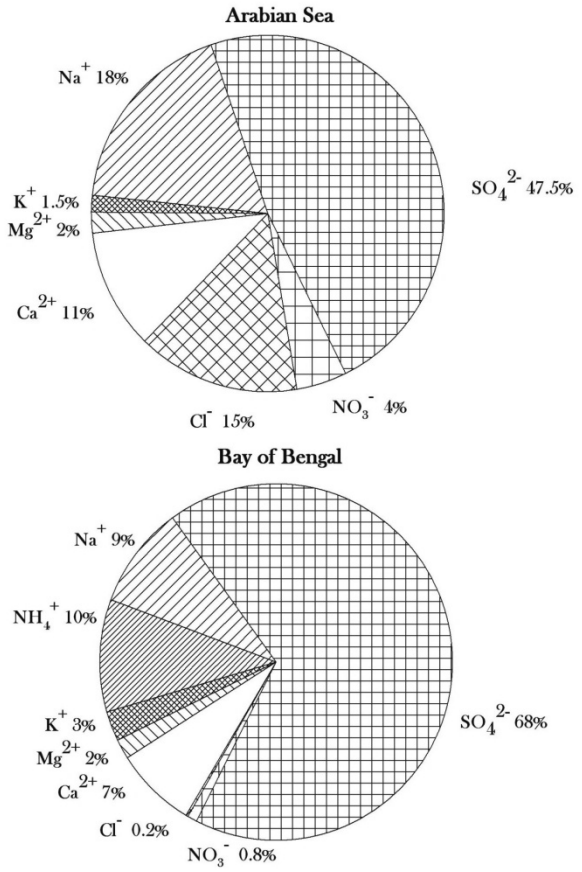


Figure 9 : Average water-soluble composition of aerosols over the Bay of Bengal and the Arabian Sea, reflecting dominance of SO_4^{2-}

The water-soluble species, on an average, account for 44% and 33% of TSP over BoB and AS respectively, with a dominant contribution of SO_4^{2-} over both the regions

(Figure 9). However, distinct differences with respect to elevated abundances of NH_4^+ in the MABL of the BOB and that of Na^+ and Ca^{2+} in the AS were seen. The nss-Ca^{2+}/nss-SO_4^{2-} (nss non sea salt) equivalent ratios in BoB and AS range from 0.12 to 0.5 and 0.2 to 1.16 respectively, and provide evidence for predominance of anthropogenic constituents and chemical transformation processes occurring within MABL. The concentrations of OC and EC average ~1.9 and 0.4 µg m^{-3} in the BoB exhibit a decreasing trend from north to south. However, abundance of the carbonaceous species are not significantly pronounced over AS. The abundance of Al (used as a proxy for mineral aerosols), varied from 0.2 to 1.9 µg m^{-3} over BoB and AS, with distinctly different spatial pattern – decreasing north to south in BoB in contrast to increasing pattern in AS. This study has implications to the potential role of dust in the acid uptake process in MABL.

(Ashwini Kumar, M.M. Sarin and A. K. Sudheer)

Characterization of Fine and Coarse Mode Aerosols in Urban Atmosphere

The PM_{10} (coarse) and $PM_{2.5}$ (fine) aerosol samples were collected on a daily basis during December 2006 at Ahmedabad (23.1 ^oN 72.6 ^oE; 55 m asl) in order to study size-dependent distribution of chemical species in an urban atmosphere. The abundance of PM_{10} ranged from 121 - 327 µg m^{-3}, whereas, $PM_{2.5}$ ranged from 32 - 106 µg m^{-3}. On an average, $PM_{2.5}$ constitutes ~33 % of PM_{10} mass (range: 23 - 44 %) demonstrating the dominance of coarse mode aerosols in an urban atmosphere during wintertime. A significant increase in the mass concentration is observed when the winds were easterlies and the air mass originated from the central India. The concentrations of NO_3^- and SO_4^{2-} in fine mode ($PM_{2.5}$) varied from 0.4 to 2.1 µg m^{-3} and 3.2 to 22.5 µg m^{-3} respectively. The abundance of SO_4^{2-} exhibits a significant correlation with NH_4^+, indicating that SO_4^{2-} gets neutralized with NH_4^+ almost quantitatively. The low contribution of Ca and Mg to the total soluble fraction in $PM_{2.5}$ aerosol implies insignificant contribution of mineral dust. Unlike fine aerosols, NO_3^- and SO_4^{2-} in coarse mode show a linear trend due to the neutralization of mineral dust with acidic species.

(R. Rengarajan, M.M. Sarin and A.K. Sudheer)

Atmospheric Carbonaceous Species: Role of Secondary Organic Carbon

Atmospheric carbonaceous species, comprise elemental carbon (EC) with variable amounts of organic carbon (OC) and trace metals, have been the subject of numerous regional and global modeling studies on climate change. A systematic study by sampling through a network of stations, provided the first data set on atmospheric abundances of EC and OC over northern and western India. This study suggests that total carbonaceous aerosols (TCA=1.6*OC+EC) contribute significantly to the particulate mass (PM) at urban locations (about 30-35% of PM). In high-altitude sites, TCA is the second largest contributor (~15-25% of PM) after mineral dust, with EC contribution ranging from 2 to 5% of PM. A notable feature of the data from various sites is reflected in the form of pronounced temporal variability in the abundances of the particulate carbon species with higher concentrations occurring during winter months and lower during summer time. Additionally, frequency distribution of OC/EC ratios shows consistently high values (by factor 3 to 4) as compared to typical ratios in urban aerosols (OC/EC ~2) under the influence of primary emission sources (Figure 10). This brings out the significant role of OC and secondary organic carbon (SOC) to the atmospheric carbonaceous species from local biomass burning sources. Such higher OC/EC ratios (~ 6 to 8) and enhanced

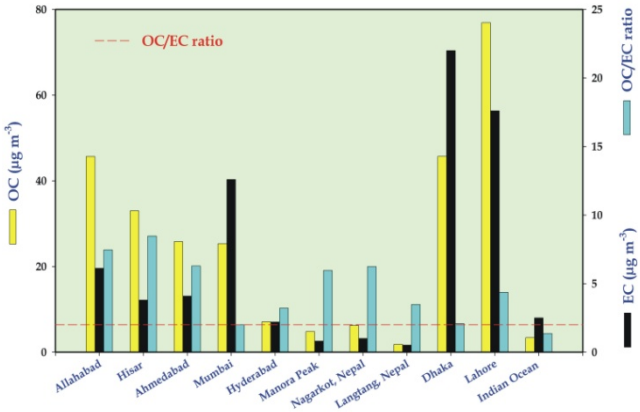


Figure 10 : ~2EE concentration versus salinity in the Narmada, Tapi and Mandovi estuaries

contribution of SOC require reassessment of their parameterization in the regio-nal and global scale models.

(Kirpa Ram, R. Rengarajn, M.M. Sarin and A. K. Sudheer)

Trace Elements and Isotopes (TEIs) in Indian Estuaries

The Narmada, the Tapi and the Mandovi estuaries along the Arabian Sea coast and the Hooghly estuary (along the Bay of Bengal coast) were sampled to understand the behaviour of trace element and their isotope systematics in these regions (Figure 11). Towards this, measurement procedures for measuring REE by ICP-MS and $^{87}Sr/^{86}Sr$ by TIMS were established. In all the estuaries, Re exhibited a conservative behaviour. The Re concentration of seawater end member for the the Bay of Bengal and for the Arabian Sea were nearly identical and overlaped with the open seawater value in the Arabian Sea (~40±1 pmol/kg), These are consistent with the values from other oceanic regions. In contrast, the seawater end member Re concentration of the Arabian Sea estimated based on the Tapi and the Narmada estuary samples ranged from, 100 to 200 pmol/kg. The results indicate a N-S gradient in the

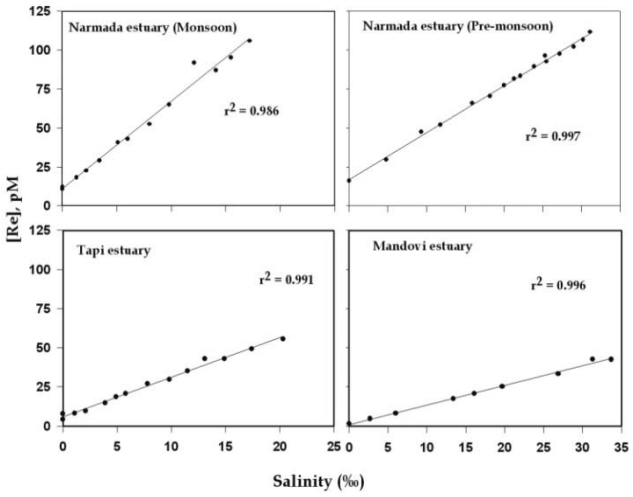


Figure 11 : Rhenium concentration versus salinity in the Narmada, Tapi and Mandovi estuaries

Arabian seawater with higher Re towards the north. Furthermore, the data shows temporal variation with higher values during monsoon. Potential sources for the high Re in the northern Arabian Sea water can be (i) discharge of Re rich wastes, from industries/refineries and, (ii) resuspension of Re rich sediments in oxic waters resulting in release of Re from sediments to water. The impact of such coastal sources on open ocean Re abundances particularly during monsoon is being evaluated.

(Waliur Rahaman and Sunil K. Singh)

Weathering in the Himalaya, Gangetic Plain and Peninsular Drainage

(a) Erosion in the Himalaya : Temporal variation via inverse modeling.

Samples from the headwaters of the Ganga (the Alaknanda, Bhagirathi and the Ganga) were analysed for their dissolved major ions, Sr and $^{87}Sr/^{86}Sr$ on a biweekly basis over a year to determine temporal variation in chemical erosion in their basins. The data shows significant seasonal variation in concentrations of major ions and Sr, with lower values during monsoon, in contrast to, increase in water discharge during monsoon, by a factor of ~20. $^{87}Sr/^{86}Sr$ of the streams also shows a seasonal trend with higher value during lean flow indicating relatively more silicate contribution during non-monsoon months. To quantify the silicate-carbonate erosion rates, source apportionment of the dissolved loads was done using both forward and inverse models. The cations contribution from silicates for the Ganga, Alaknanda and Bhagirathi varied from 18 to 28, 18 to 27 and 20 to 42% respectively, with higher values during lean flow periods. The results obtained by forward and inverse model overlaps within the uncertainties. A unique approach to quantify the loss of Ca from these streams was made using the results of inverse model, which show that ~50% and 20% of Ca is lost via calcite precipitation from the Ganga and Alaknanda respectively during lean flow.

This work is being done in collaboration with Prof. G.J. Chakrapani, IIT Roorkee.

(b) Weathering in the plains : A significant fraction of the drainage of the Ganga in the plains and the peninsular rivers are affected by alkaline and saline soils, containing several Na salts. These salts could be a potential source (or sink) of Na to the Ganga, thereby contributing to uncertainties in the estimates of erosion rates. The total chemical erosion rate (CER) estimated using Ca, Mg, K and SiO_2 abundances vary from ~15 to 24 million t/y in the Gangetic plain and ~ 10 and 16 million t/y in the peninsular drainage. The CER in Himalaya is 3-4 times higher compared to those of the plain and the peninsular drainage. Higher erosion rates in the Himalayan drainage are due to higher relief and higher runoff. Despite the lower CER, the flux of dissolved material from the Gangetic plain and the peninsular drainage is more than that from the Himalayan drainage. This study highlights the importance of weathering in the Ganga plain and peninsular region in contributing to the elemental and isotope budget of global ocean and uncertainties that can arise from the use of Na ion to derive silicate weathering rates.

(Vineet Goswami, S. Krishnaswami, Santosh K. Rai, Sunil K. Singh and Gyana Ranjan Tripathy)

Monsoon Reconstruction using Speleothems

Speleothem samples from the Dandak cave, Chhattisgarh, central India, were dated using ^{230}Th-^{234}U mass spectrometry. A near-annually resolved record of the Indian summer monsoon rainfall variations was reconstructed by analysis of the oxygen isotope ratios for the core monsoon region of India. This record, spans 600 to 1500 A.D., and thereby includes the Medieval Warm Period and the Little Ice Age. It shows that the modern instrumental record significantly underestimates the natural monsoon variability. Periods of severe drought, lasting for decades, occurred during the fourteenth and the mid-fifteenth centuries, coinciding with several of India's most devastating famines.

This work was done in collaboration with Ashish Sinha, Kevin G. Cannariato and Lowell D. Stott from University of Southern California, USA.

(R. Ramesh and M. G. Yadava)

Iron Enrichment Experiments in the Southern Ocean

We carried out bottle scale iron enrichment experiments in the Southern Indian Ocean, using ^{15}N tracer technique coupled with iron enrichment. These experiments suggested that,

(i) Addition of iron, in the iron depleted areas, does not enhance productivity on first day but this increases with

time. In contrast, addition of iron in areas with sufficient bio-available iron (35°S), decrease the productivity,

(ii) Iron enrichment enhances nitrate and urea uptake more compared to ammonium during the initial phase in iron limited areas. During the later phases, the ammonium uptake increases. The f-ratio (ratio of new production to total production) shows a marginal increase because the enhancement in the nitrate uptake is balanced by an equal increase in the urea uptake,

(iii) Though iron enrichment increases the productivity in High Nutrient Low Chlorophyll (HNLC) waters, no such monotonic increase is seen in the f-ratio and hence in the export productivity.

These experiments were carried out in collaboration with NCAOR, Goa.

(R. Ramesh and Satya Prakash)

Spatial Variation of Hydrogen Isotopes and Salinity in the Southern Indian Ocean

Stable isotope ($\delta^{18}O$ and δD) and salinity measurements on the surface waters of the Southern (Indian) Ocean during the austral summer (25th January to 1st April, 2006) on board *R/V Akademik Boris Petrov* were carried out to investigate the relative dominance of processes such as evaporation, precipitation, melting and freezing over different latitudes (Figure 12). The region between 41°S

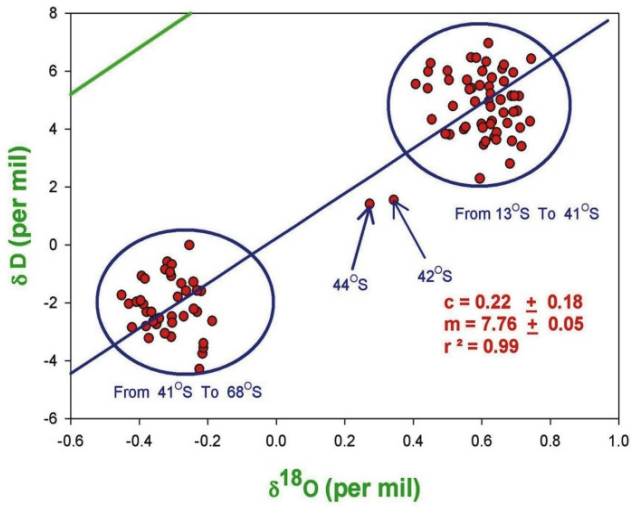


Figure 12 : Stable hydrogen and oxygen isotope ratios of sea water from the southern Indian Ocean defining two clusters, one above 41°S and the other below 41°S. Blue line is the best fit and the green line is Global Meteoric Water line

and 45°S is a transition zone. Region north of 41°S is dominated by evaporation/precipitation process while that south of 45°S (up to Antarctica) is dominated by melting/freezing processes. Further, a combined study of stable oxygen and hydrogen isotope ($\delta^{18}O$ and δD) indicates that the Southern Ocean evaporates under non-equilibrium conditions.

(R.A. Jani, R. Ramesh and R. Srivastava)

Carbon Turnover in Soils

The radiocarbon laboratory investigated about 50 samples of soils, sediments, speleothems and charcoals to estimate ^{14}C ages. This laboratory also successfully participated in the final round of the Fifth International Radiocarbon Inter-comparison (VIRI) wherein unknown age samples were provided to us for age determinations.

Two important results are : the top 1 to 2 m of land surfaces have a significant amounts of organic carbon, residing in the host minerals and keep these decaying due to complex biological and chemical degrade-ation processes. Using radiocarbon as a natural tracer, the mobility and storage of organic carbon in natural dense forest soils of Jagdalpur, Chhattisgarh (18°55'N, 81°51'E) were estimated. Twenty measurements on two soil sections, ~100 m apart indicated the presence of the bomb carbon in the top ~8-10 cm of the profile. This indicates that recent organic carbon is stored and then removed back by decomposition at a rapid rate, possibly on a decadal scale. Also, deeper layers (10-80 cm) of soils seem to preserve organic carbon for longer durations.

(Amzad Hussein Laskar, R. Ramesh, M.G.Yadava)

Strengthening of Northeast Monsoon during LGM: Evidence from Sr and Nd Isotopes

Two AMS radiocarbon dated sediment cores were analysed for Sr and Nd isotopes. These cores were from the central and the southern Bay of Bengal and provided a record of past climatic variation for the last 50 kyrs. The variations in the $^{87}Sr/^{86}Sr$ ratio and Nd isotopic composition in the sediments of the Bay of Bengal reflect the changing proportion of sediments from the Himalayan sources and the Irrawaddy river. Higher $^{87}Sr/^{86}Sr$ ratio (0.718-0.719) is attributed to the Himalayan source sedi-ments. Irrawaddy sediments had $^{87}Sr/^{86}Sr$ ratio of ~0.713 and that of Arakan

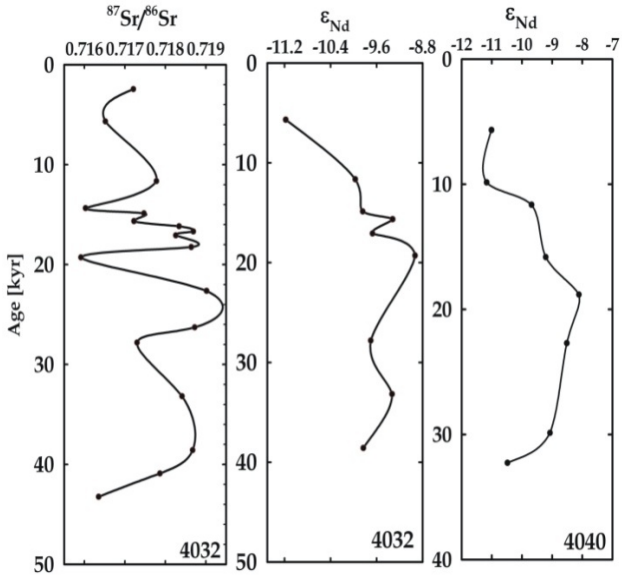


Figure 13 : Downcore variation of $^{87}Sr/^{86}Sr$ and ε_{Nd} in the Bay of Bengal Cores

Coast is 0.716. The ε_{Nd} in the silicate fraction of the core 4032 varied from -10 to -8.9 and that in the core 4040 from -11 to -8. The high ε_{Nd} values of -8.9 in the core 4032 and -8.0 in 4040 corresponds to 20 kyr (Figure 13). The western fan of the Irrawaddy River draining through Arakan Coast is a likely contributor for high radiogenic ε_{Nd} to the Bay of Bengal. Based on above, it is suggested that during the Last Glacial Maximum LGM, strengthened Northeast Monsoon brought higher sedi-ment flux from the Arakan Coast routed through Irrawaddy River in to the Bay of Bengal. Thus, together with the Sr and the Nd isotopic variation in the two sediment cores, it can be inferred that compared to the present, during the LGM the north east monsoon was stronger, and the Southwest Monsoon was weaker.

The AMS radiocarbon dates were provided by Drs. A.J.T. Jull and G.S. Burr of NSF-AMS Facility of University of Arizona, Tucson, USA.

(R. Bhusan and Sunil K. Singh)

Rapid Vertical Mixing in Deep Waters of the Andaman Basin

The Andaman Basin is an enclosed region in the northeastern Indian Ocean with horizontal ventilation of deep water below ~1800 m nearly isolated by the Andaman-Nicobar Islands and associated ridge systems. This separates it from the Bay of Bengal. The physical and chemical properties, including radiocarbon (^{14}C) measured at two stations of the Andaman Basin show negligible variation with depth in the waters below 1300 m, indicating well mixed waters. Model calculations based on ^{14}C profile measurements indicate rapid vertical mixing (vertical advection velocity, w >200 m.yr^{-1}) in waters deeper than 1800m of the basin. For a basin with deep water thickness of 1000 m below 1800 m, deduced mixing rate of >200 m.yr^{-1} translates to mixing time of < 5 yrs. The possible mechanism responsible for such high vertical mixing rates could be the internal waves generated from tidal currents flowing through rough topography. In addition, Andaman Basin is underlain with a young crust and is known for its high heat flow. This could additionally contribute to a higher vertical mixing.

This work was done in collaboration with K. Dutta, Institute of Physics, Bhubaneshwar.

(R. Bhushan)

Chronology of Paleoseismic Events

Palaeoseismic studies involving, 1) dating of fault gouge (FG), 2) fault scarps, 3) sediments from abandoned rivers and, 4) laboratory simulation of pressure condition during sand dyke injection were carried out. Samples from eastern lesser Himalaya, the Great Rann of Kutchch and granitic quartz, were analyzed using the Thermoluminescence (TL) and Optically Stimulated Luminescence (OSL) dating techniques. Fault gouge dating using fine grain extracts from the Gish fault and its associated host rock gave palaeodoses of 20–63 Gy for the fault gouge, about a tenth of ~206 Gy for the host rock, suggesting resetting of luminescence signal and that the faulting occurred at ~2 ka. However, host rock gave an luminescence age, substantially lower than the anticipated age of >Ma suggesting athermal fading. Application of the fading correction provided 3 ka age of faulting event, however for host rock samples, correction was not possible as the fading correction was large. In the Great Rann of Kutchch, a 4–6 m high and ~90 km long fault scarp, known as the Allah Bund was created due to a M_w ~8 earthquake in 1819. This raised local base level that beheaded the streams via changes in local lopography. Optical dating of fault scarp sediment and beheaded channels suggests at least two major earthquakes prior to the 1819 Allah Bund event, dated to 3 ka and 2 ka respectively. This suggests a periodicity recurrence interval of 1-1.2 ka for such large earthquakes. Laboratory studies to simulate pressure (stress) excursion during a sand dyke injection using bright quartz sample were performed. The sample was stressed by dropping the weights from different heights. TL and OSL measurements on the stressed samples indicated a decreasing trend in the signals due to repeated stress, implying that TL/OSL resetting is possible if there was multiplicity of stressing events.

This work was done in collaboration with, Dr. Malay Mukul, Dr. B.K.Rastogi, Dr. N. Porat Mr. M.S.Gadhvi.

(A.K.Tyagi, N.Juyal and A.K.Singhvi)

New Possibilities in Luminescence Dating: Extended Range and the Dating of Surfaces

The possibility of extending the dating range of luminescence method was explored and three approaches were examined. The first was to use the luminescence emissions in the red window. Though, emission in the red window show some improvement, overall absence of a high temperature peak in the red window provided difficulties.

The second was the analysis of large grains, for which detailed Monte Carlon-particle (MCNP) Simulation of dose rate with in the grain was carried out and were coupled to optical transparency. The basic idea was to use the attenuation of the beta dose with depth in a large grain such that, in the interior only the gamma dose is the contributor to the luminescence signal. Optical transparency of large grains is to be examined as these may provide a limiting factor for the predepositional bleaching.

The third approach was to date buried surfaces, grain cross sections and complex samples using an electron multiplier CCD imaging approach. The basis system is being made operational and it is hoped that in the coming months, this system will provide results. Analysis of quartz and feldspar

grains from samples of different antiquity has been done to determine the fading rates for feldspars and a model is being developed to use sensitivity change as a surrogate for the luminescence decay.

The work on MCNP simulation was done in collaboration with Dr. R. M. Mayya, and his group at BARC, Mumbai.

(N.Chauhan, R.H. Biswas, Y.C.Nagar and A.K. Singhvi)

Geology and Geochemistry of Deccan Trap Dykes and Sills around Pachmarhi, Central India

Deccan Traps of India are one of the major continental flood basalt provinces of the world. These represent fissure type eruptions on a grand scale, and dense mafic dyke swarms exposed in the province most likely represent the eruptive fissures. Unfortunately, a majority of these dykes have not been studied for their chemical fingerprints so as to be correlated with the lava flows. In an effort to contribute to this aspect, geological and geochemical study of Deccan Trap dykes and sills around Pachmarhi, central India was initiated. Major element geochemistry of the intrusions is found to be completely subalkalic, similar to majority of Deccan flood basalt lavas. Based on their major element and trace geochemistry, it was inferred that the dykes and sills served as feeders to the lavas, particularly the lavas of the eastern and northeastern Deccan Traps. We identified dykes and sills in the Pachmarhi area with chemical signatures, corresponding to the lava piles with Poladpur-, Khandala- and Ambenali-type, The initial $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ isotopic ratios of these dykes, except for one sample, defined a completely different field, diversifying from the normal Deccan trend in a co-variation plot. Some of the samples do plot in the field of the Jabalpur lava flows indicating that we may have finally discovered the feeder systems for these southeastern margin flows of the Deccan Traps.

This work was done in collaboration with Dr. H.C. Sheth from IIT, Mumbai.

(J.S. Ray, A.D.Shukla and Alok Kumar)

U-Pb Geochronology of Authigenic Xenotimes from Huronian Supergroup, Canada

U-rich diagenetic xenotime overgrowths on zircons can be dated to yield minimum estimates of depositional ages of non-fossiliferous siliciclastic sedimentary rocks. The Huronian Supergroup, Canada was deposited during a key interval of Earth history marked by increasing oxygenation of the atmosphere, and deposition of three separate glaciogenic deposits (e.g., Gowganda Formation). The Huronian is poorly constrained between 2.45 Ga and 2.22 Ga. To better constrain its age, the age of the glaciations and to explore a possible link with oxygenation of the atmosphere, diagenetic xenotime was dated from samples of the McKim, Mississagi, Gowganda, Gordon Lake and Bar River formations. The ^{207}Pb - ^{206}Pb age of the majority of xenotime growths, irrespective of their stratigraphic position, can be attributed to large-scale basinal fluid-flow events that significantly post-dated deposition. Prominent age peaks at 2.2 Ga and ~1.7 Ga, correlate with intrusion of Nippising diabase sills and orogenic activity to the south, respectively. However, two xenotimes (seven analyses) from the Gordon Lake formation, stratigraphically above the Gowganda glaciogenic deposits, yield an older age of 2376±13 (2σ) Ma. Although, there is a remote possibility that these overgrowths are detrital, their irregular habit and sharp edges support an interpretation in favour of authigenic growth. If this date represents the minimum depositional age for the Gordon Lake Formation, the Gowganda glaciation is older than potentially correlative glaciogenic deposits in southern Africa and therefore cannot be related to a single Paleoproterozoic "Snowball Earth" scenario.

This work was done in collaboration with R.H. Rainbird and W.J. Davis of Geological Survey of Canada, Ottawa.

(J.S. Ray)

Planetary Science and Exploration Programme

Planetary Science and Exploration Programme aims at developing new science initiatives in the subject as also develop technology and human resource to achieve this. The principal focus during the last year was on the development and testing of the qualifying model and flight model of the High Energy X-ray (HEX) payload for Chandrayaan-1 mission. Laboratory investigations of meteorites, analysis of remote sensing hyperspectral data and simulation studies were also carried out to better understand the natural and induced nuclear radiations from planetary surfaces. Activities towards formulating and design of payloads based on nuclear techniques, for future planetary missions of ISRO, were also initiated.

HEX Payload for Chandrayaan-1 mission

The High Energy X-ray (HEX) spectrometer, is a scientific payload to be flown in ISRO's Chandrayaan-1 mission scheduled for launch in 2008. This has been designed to study X-rays from the lunar surface in the energy range 30-270 keV using pixilated Cadmium Zinc Telluride detector arrays. Signal generated by the photon incident on any of the 2304 individual pixels in 9 arrays of 256 pixels each are read out using ASICs coupled with the detector that allows identification of the triggered pixel and energy of the incident photon. ASIC current outputs are proportional to the energy of the incident photon, also contain information on the position in terms of pixel address. Other information is processed by the Front-End Electronics (FEE). Energy information is digitized by 10-bit ADC and sent to processing electronics for transmission of the data. CZT detector arrays are biased by a suitable HV bias voltage. In order to keep background events to a minimum, an anticoincidence system (ACS) using standard CsI(Tl) scintillators placed around the CZT detector arrays is used. Background/partially-absorbed events that are simultaneously detected in the CZT detectors and ACS are logically blocked from further analysis. Signals from HEX detector package are sent to HEX Data Interface Package (HEXDIP) which interfaces with spacecraft mainframe systems comprising power, telemetry, tele-command and the bulk onboard storage system, the Solid State Recorder (SSR). The flight payload weighs ~15 kg and dissipates 25 W power. The CZT detector card, front end electronics and HV bias generator were designed and fabricated by PRL while ACS and HEXDIP were designed by Space Astronomy and Instrumentation division of ISAC.

A major effort during this year was to fabricate, test and qualify the HEX package, which should be exactly similar to the flight model and then fabricate the flight model. All CZT detectors were tested for their dependence on temperature and were rated for their suitability for use in

flight qualification models. The HEX package trays were made with Mg alloy and printed circuit boards were populated with all mil-grade/space qualified components. The qualification model was first bench tested, then subjected to vibration (sine and random, all three axes) and thermovac test at levels specified for qualifying the package. The primary specifications i.e. energy resolution (10% at 60 keV) and detection threshold (≤ 30 keV) were adequately met. After the successful test of qualification model, the flight model was fabricated and tested for all environmental checks at acceptance levels. The flight model will soon be integrated with the spacecraft. Software necessary for the analysis of laboratory data as well as expected flight data was developed.

Figure 14 shows the HEX package mounted on the vibration table.

(Y. B. Acharya, S. Vadawale, M. Shanmugam, D. V. Subhedar, S. Purohit, V. M. Shah, S. L. Kayastha, V. J. Vaibhavi and J. N. Goswami)

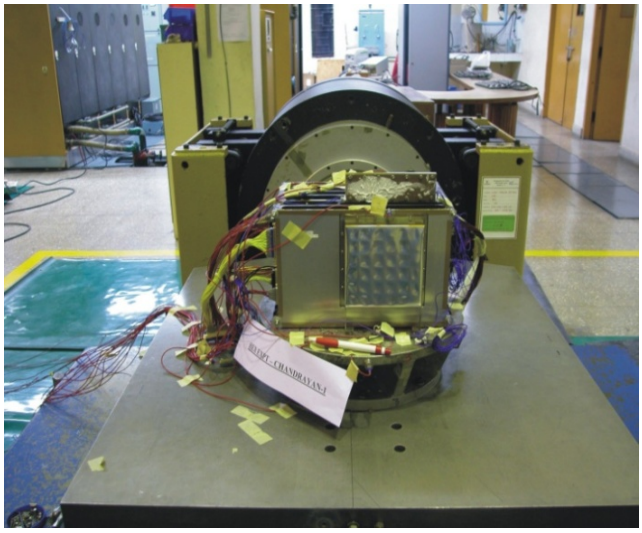


Figure 14 : HEX Payload mounted on vibrational Table for test at ISAC, Bangalore.

Hyperspectral Data Analysis of Terrestrial Rocks

Hyperspectral datasets in visible and infrared (0.4-2.45 μm) for the Moses Rock region in USA obtained by Airborne Visible Infrared Imaging Spectrometer (AVIRIS) were analysed to generate mineral maps of the region using different approaches. This study is aimed to understand the complexities involved in extracting useful information from a complex spectrum as a prelude to extraction of data from imaging spectrometers onboard Chandrayaan-1. It was seen that the selection of wavelengths for generating band ratio images is critical in the case of hyper-spectral datasets and that it depends on the set of minerals that one wants to discriminate. Two different ratios to identify the same mineral differ in degree of discrimination for that mineral. It is therefore essential to evaluate all possibilities for mineral identification.

(Deepak Dhingra)

Potential Landing Sites for Future Lunar Exploration

Lunar missions are being planned by several space agencies to better understand the origin and evolution of the Moon, and explore the possibility of utilization of lunar resource and the use of Moon as a platform for launching inter-planetary missions. An orbiter-lander-rover configuration is being considered by ISRO to be sent to the Moon in the near future with specific science objectives. Towards this, several locations on moon were evaluated for detailed investigations by lander/rover, based on the available datasets that include elemental and mineralogical abundances and topographical information. Two terrains were identified in terms of their scientific importance and geological diversity. These are Procellarum-KREEP Terrain (PKT) and South Pole Aitken Terrain (SPAT). In-depth study of targeted sites within these two regional units would enhance the understanding of the lunar evolution.

Based on their scientific returns and technical feasibility, a list of eight promising locations outside PKT and SPAT were also short listed (Figure15). These were : Aristarchus Region – one of the geologically diverse region near crater Aristarchus having basalts, pyroclastics and volcanic constructs; Mare Moscoviense – one of the very few far side locations having widespread exposure of basalts along with pyroclastics and swirls; Olivine hill - located near the center of SPA basin as it might have exposed rocks from lower crust-upper mantle; Compton-Belkovich Th Anomaly–has the highest Th concentration on Moon possibly indicating presence of an evolved lithology; Basalts near Crater Lichtenberg – one of the youngest basalts; Crater Tsiolkovsky – crater filled with basalts, central peaks

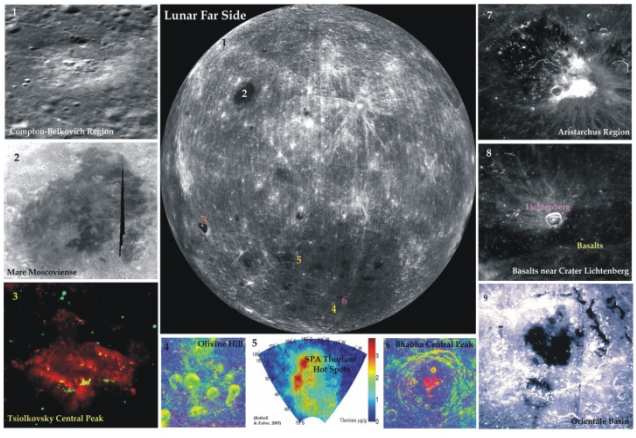


Figure 15 : Potential landing sites, in terms of scientific importance, on the lunar globe (both front and back) for the Chandrayaan-2 Lander/Rover.

have Anorthosite - Olivine contacts;. Scaliger – indicates occurrence of a pluton; Central peaks of crater Bhabha – dominantly comprising orthopyroxene which is unique exposure. Detailed studies using datasets from the SELENE, Changè-1, Chandrayaan-1 and LRO missions would facilitate in further evaluation of these landing sites.

(Deepak Dhingra and Neeraj Srivastava)

Chemical, Petrological and Isotopic Investigations on Recent Indian Meteorite Falls

Recently two meteorites fell in India, These were, (1) an iron meteorite in Kavarpura, Rajasthan (Aug. 29, 2006) and (2) a chondrite in Mahadevpur, Assam-Arunachal Pradesh border (Feb. 21, 2007). A single piece (6.8 Kg) of the Kavarpura iron meteorite and at least four large fragments of the Mahadevpur meteorite (3.4, 60.2, 3.8, 3.1 kgs) were recovered. Petrological, chemical and isotopic characterization of these meteorites using electron probe micro-analyser (EPMA), X-Ray Fluorescence (XRF) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) techniques was carried out. Mahadevpur **:** The mineral chemistry of various phases of the meteorite suggests that ortho-pyroxene is dominant in pyroxenes. Olivine in chondrules and matrix do not show compositional variation, suggesting that the meteorite is an equilibrated chondrite. Back scattered electron (BSE) images indicated that the chondrule boundaries were not well defined and chondrules were fragmented, showing a brecciated structure. The matrix comprised a heterogeneous mixture of chondrule fragments, olivine, pyroxenes and plagioclase. Porphyritic and radiating pyroxene chondrules were seen in BSE images (Figure 16).

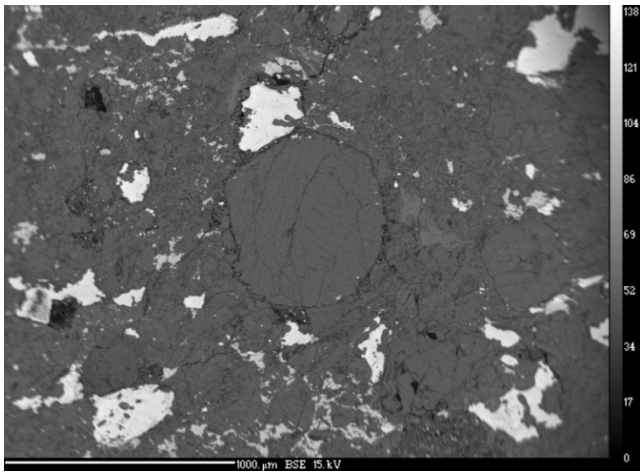


Figure 16 : Back scattered electron image of a thin section of Mahadevpur chondrite (H4/5). A chondrule can be clearly seen at centre. Lot of metel blebs (white patches) are visible in the section.

Based on the Fa (18-20 mole %) and Fs (14-16 mol %) contents, Mahadevpur meteorite is classified as H chondrite. Oxygen isotopic composition (measured at the University of California, San Diego, by laser flouri-nation technique) indicated a $\Delta^{17}O$ value of 0.857 ‰ and supported the classification as H chondrites. Cosmogenic noble gases provided an exposure age of 6 Ma for Mahadevpur. Moderate amounts of trapped Ar, Kr and Xe in Mahadevpur suggest a metamorphic grade 4 or 5.

Kavarpura - Polished and etched surface indicated Widemanstätten pattern with fine teanite band widths. Optical microscopic observation revealed inclusions ranging in size from few tens of microns to few hundred microns across on the polished surface (Figure 17).

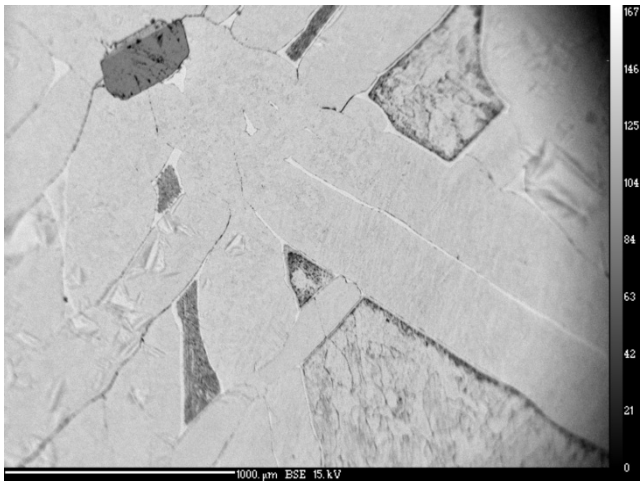


Figure 17 : Back scattered electron image of a polished and etched section of the Kavarpura iron meteorite, showing bands of kamacite and teanite and non-metallic inclusions of few tens of microns size.

Qualitative electron probe microanalysis (EPM) studies show that some of the inclusions are C rich and some are rich in Si, Cr and P, in addition to Fe, Ni. Preliminary data on siderophiles (Ni 9.5%, Co 0.39%, Ir 1.6 ppm, Ga 6.8 ppm and Ge 5.8 ppm) by ICP-MS and the presence of non-metallic inclusions suggestes that Kavarpura can be classified as IIE-Anom. An interesting feature of this meteorite is the presence of Solar Noble Gases.

(V. Mahalingam, D. Panda, K. Durga Prasad, A.D. Shukla, P. N. Shukla, S.V.S. Murty, R. R. Mahajan, Suruchi Goel and V.K. Rai)

Solar Modulation of Cosmic-ray induced Dose-rate in a Martian Soil Profile

It is well known that the transport of magnetic fields by solar plasma within the entire heliosphere is effective in producing a strong modulation of galactic cosmic ray flux. We used modulation theory to estimate spectral shape and fluxes of galactic cosmic ray (GCR) protons to determine the total GCR dose-rate for different solar modulation levels (M) using a Geant 4 code. This code simulates a 50 km Martian atmosphere and a 5 m soil profile. The composition of the Martian soil profile is based on the results of alpha-proton X-ray spectrometer on Pathfinder-Sojourner. Our results suggest that total GCR induced dose-rate at the Martian surface is ~43 mGy a^{-1} for average solar activity (M = 600 MeV). Subsequently, the dose-rate decreases monotonically to ~0.5 mGy a^{-1} at a depth of 3 m. These estimates of the surface dose-rate are similar to ~51 mGy a^{-1} obtained by McKeever and co-workers using the HZETRN code (if normalization errors are taken into account). We estimate the GCR dose-rate to be ~65 mGy a^{-1} and ~30 mGy a^{-1} at the martian surface for solar minimum (M = 300 MeV) and solar maximum (M = 900 MeV) conditions respectively. These values are comparable to ~78 mGy a^{-1} and 25 mGy a^{-1} obtained previously by McKeever and colleagues. These

studies will help to improve the accuracy of the luminescence ages of surface and near-surface martian sediments.

(D. Banerjee)

Simulation of Effective Dose-rate from GCR and SEP Events inside a Spacecraft Module

ISRO is planning for a manned spacecraft into low earth orbit in the near future. The assessment of effects of space radiation on astronauts is an important concern in this mission. A strategy to protect the astronauts is to design appropriate shielding solutions for the spacecraft modules. A computer code was written using Geant 4 to simulate the crew module structure and shielding design. The code used a particle gun to generate primary protons at a random position above the crew module structure. These particles are then given a momentum direction such that the particle impacts any random location within a 1 cm^2 area at the centre of the upper surface of the top layer in the crew module structure. The energy spectra and fluxes of the incident protons were calculated using the CREME 96 solar quiet environment model for solar minimum, solar maximum and solar average conditions, assuming quiet geomagnetic conditions, and a 45.5^o inclina-tion, 275 km circular orbit. The solar energetic (flare) proton spectra fluxes were estimated using the "worst-day" (20-21 October 1989) CREME96 SEP model, for both quiet and stormy geomagnetic conditions, assuming the above orbit. The simulation results suggest that the dose-rate estimates for quiet geomagnetic and solar quiet ("no flare") conditions are lower than safe limits for humans for the given orbit, and the proposed shielding design. Additionally, during stormy geomagnetic conditions, the dose-rate from solar energetic (flare) protons for the above orbit is estimated to be ~0.052 cSv/d, implying an integrated dose of ~0.36 cSv for a 7 day mission. This value is also negligible in comparison to the 30-day safe dose limits of ~0.25 Sv, 1 Sv, and 1.5 Sv for human bone-marrow, eye and skin respectively.

(D. Banerjee)

Solar Physics

The research and development activities of the Udaipur Solar Observatory revolve around the central theme of solar activity and solar eruptive processes. Helioseismology is used as a tool to dig into the sub-surface origins of eruptions. Surface magnetic field is measured to monitor magnetic energy storage and evolution of the potential triggers of the eruptions. Above the surface, chromospheric and coronal phenomena are used to predict the geo-effectiveness of these eruptions. A combination of analyses of archived data, mathematical modeling and construction of sophisticated instruments is employed to achieve the desired goals.

High Frequency Velocity Oscillation Enhancement during a Large Solar Flare

Solar flares can excite velocity oscillations in the Sun. The first detection of `solar quakes' inside the Sun was reported during the X2.6 flare of July 9, 1996 using the SOHO/MDI Dopplergrams. Recently, it has been shown that the correlation between X-ray flare intensity and energy in the acoustic spectrum of disk-integrated intensity oscillations (as observed with VIRGO instrument onboard SOHO) is stronger for high-frequency waves than for the usual 5-minute oscillations of the Sun. A search for similar effects in the disk integrated velocity signals at the solar surface for the major solar flare (X17.6/4B) of October 28, 2003 using the Dopplergrams from the MDI instrument onboard SOHO indicated that these velocity oscillations are enhanced during the flare in the higher frequency band (5-6.5 mHz) and a feeble or no enhancement of these oscillations in lower frequency band (2-4 mHz) (Figure 18).

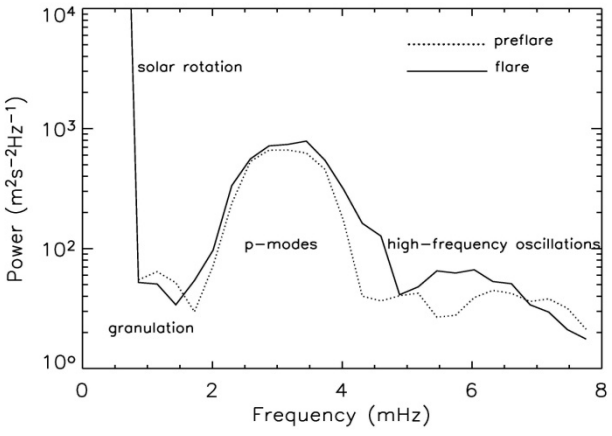


Figure 18 : Smoothed power spectrum of disk integrated velocity signals at the solar surface computed for an hour before the flare (dotted line) and that for an hour spanning the flare (solid line).

This study also illustrates the presence of high frequency power in these velocity oscillations of the Sun comparable to granulation power even in non-flaring condition. These studies will be extended to disk-integrated Doppler signals of other major solar flares.

(Brajesh Kumar and P. Venkatakrishnan)

Dynamics of Sunspot Light Bridges using High Resolution Images from Hinode

To understand the dynamics of light bridges observed in sunspots, we analysed G band and Ca II H filtergrams of two sunspot light bridges in NOAA AR 10953 obtained from the 50 cm Solar Optical Telescope on-board the Japanese satellite, Hinode on May 1, 2007. The two light bridges differ in structure. One of them resembled the filamentary penumbra and the other possessed a dark central lane running along the axis of the bridge of 170 km width, close to the diffraction limit of the telescope. Velocity measurements of the light bridges using proper motion displacements of inhomogeneities (Figure 19 left panel) averaged over the entire time series, show a non-uniform flow with velocities peaking at 250 m/s and 180 m/s for the two bridges, respectively. We also observed an arch like structure over one of the light bridges in the Ca-images (Figure 19, Right Pannel). It was also seen that brightness enhancements travelled along this arch as well as along the light bridge. Observations suggest that these enhancements over light bridges could possibly be a signature of lower chromospheric heating.

(Rohan E. Louis, A. Raja Bayanna, Shibu K. Mathew,
P. Venkatakrishnan)

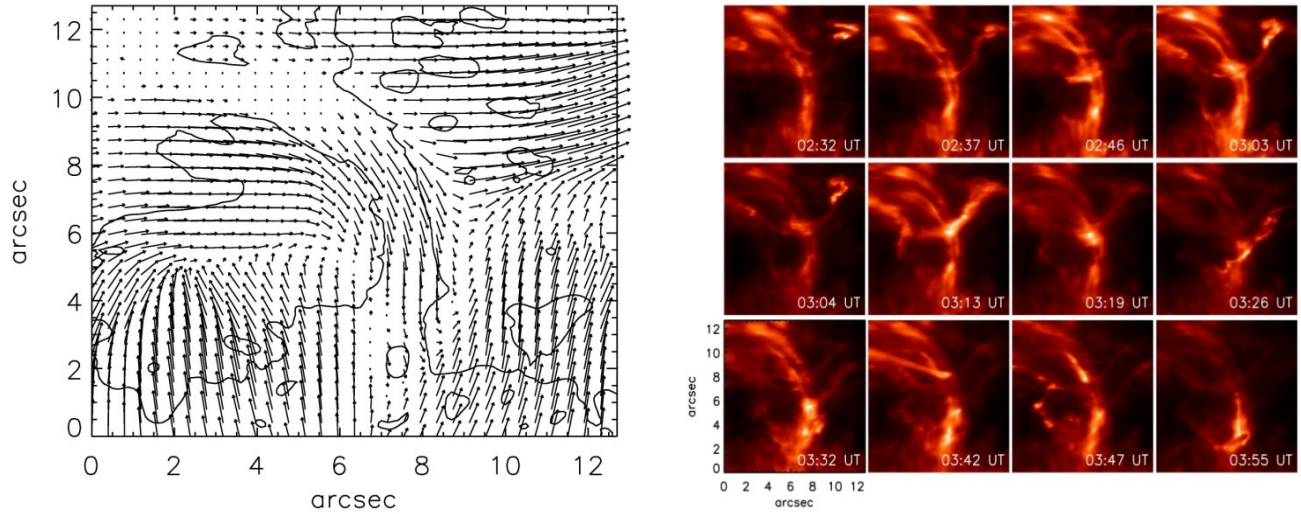


Figure 19 : Average transverse velocity map overlaid on the photospheric contour of the light bridge. The longest arrow corresponds to a velocity of 540 m/s (Left Panel). Temporal evolution of brightness enhancements over the light bridge seen in the lower chromosphere from the Ca II H filtergrams (Right Panel).

3-D Velocity Flows in Flare Productive and Non-productive Active Regions

Flows in the solar surface and subsurface at depths below solar photosphere were examined by analyzing the GONG high-resolution velocity data. The horizontal components of surface flows were obtained using the ring-diagram technique, and the subsurface flows were deduced using

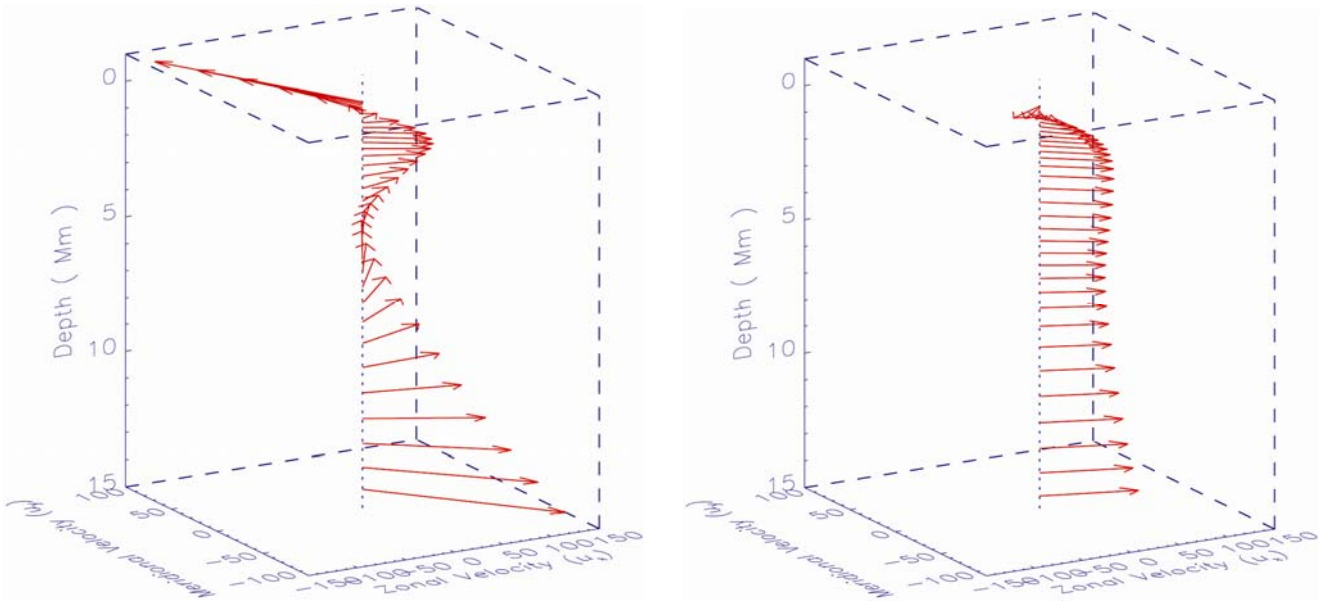


Figure 20 : 3-D view of flows in the depth of NOAA AR 10486 (Left Panel) and flows at a quiet region having same latitude and time but different longitude (Right Panel). The flow structure below the surface is evident.

inversion techniques. The surface and subsurface flows for both flare productive and relatively dormant active regions for several events were estimated. The following results were obtained, (i) flare productive active regions show strong zonal and meridional flows in their interior compared to the quiet regions (Figure 20), (ii) strong down-flows are more likely associated with locations of strong magnetic activity, (iii) The zonal and meridional velocity gradients change sign at the depth of 3-5Mm, and are likely to be associated with the production of transient activity, and (iv) a steep gradient in the meridional velocity appears in NOAA AR 10486 at a depth of around 5 Mm. This confirms our earlier work.

(R. A. Maurya and A. Ambastha)

Error Estimation in the Measurement of the Force-Free Parameter α

The force free parameter α, also known as helicity parameter or twist parameter, gives the sign of magnetic helicity. The single global value of α for a whole active region gives the degree of twist per unit axial length. However, generally significant errors accrue in the calculation of α (Pevtsov et al, 1994). To improve this situa-tion, a theoretical bipole was generated using the force-free approximation, and the propagation of error in the measurement of α was computed by adding noise of different levels to the theoretically generated magnetic field data. Stokes profiles were generated from the analytic data using the Milne-Eddington code. About 0.5% of noise is expected in the profiles by recent vector magnetographs like SOT (HINODE) telescope. The errors can reach up to 5% for other ground-based vector magnetographs. Our results show that the sign of helicity derived from the calculated α is preserved for the noise level associated with the instruments.

(Sanjiv Kumar Tiwari, Jayant Joshi, Sanjay Gosain, V.S. Pandey and P. Venkatakrishnan)

Helicity of the First Few Active Regions of the new Solar Cycle

Helicity is a physical quantity that measures the degree of linkages and twistedness in the field lines and gives the physical value of 'chirality'. We obtained helicity of the first few active regions of the new solar cycle 24. For this purpose, H-alpha images obtained at USO obtained and GONG magnetograms were used. It was found that the filaments associated with the active regions NOAA 10981 and NOAA 10990 that appeared in the northern hemisphere possessed dextral chirality. On the other hand, the filament associated with the active region NOAA 10993, located in the southern hemisphere, showed sinistral chirality. This implies that all the three active regions follow the helicity hemispheric rule (dextral in northern hemisphere and sinistral in southern hemisphere). However, some dynamo theories predict that active regions do not follow the helicity hemispheric rule in the beginning of every solar activity cycle. More data is being collected for a proper comparison of the observations with theory.

(Sanjiv Kumar Tiwari, Jayant Joshi and P. Venkatakrishnan)

Enhanced p-Mode Absorption seen near the Sunspot Umbral-Penumbral Boundary

We investigated p-mode absorption in a sunspot using SOHO/MDI high-resolution Doppler images. The Doppler power computed from a three and a half hour data set was used to study the absorption in a sunspot. An attempt to relate the observed absorption with the magnetic field

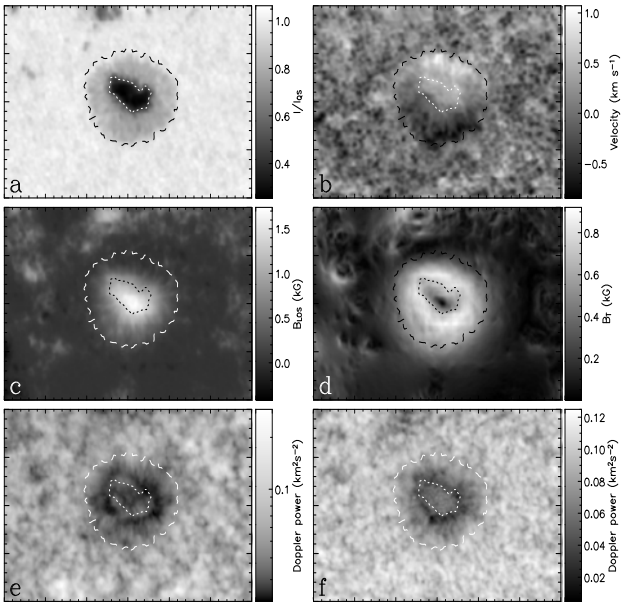


Figure 21 : Continuum intensity (a), line-of-sight velocity (b), line-of-sight magnetic field (c), computed transverse magnetic field (d), the total Doppler power in the 3 - 3.5 mHz (e) and 4.5 - 5 mHz (f) frequency bands for the analyzed sunspot. The dotted and dashed contours are the umbral and penumbral boundaries, respectively.

structure of the sunspot was made. Toward this, the transverse component of the potential field was computed using the observed SOHO/MDI line-of-sight magnetograms. A comparison of the power map and the computed potential field indicated enhanced absorption near the umbral-penumbral boundary where the computed transverse field strength is higher (Figure 21).

(Shibu K. Mathew)

Source Region of the CME of November 18, 2003

The super-storm of November 20, 2003 was associated with a high speed coronal mass ejection (CME) that originated in NOAA AR 10501 on November 18, 2003. This CME had severe terrestrial consequences in the form of a geomagnetic storm of D_{ST} index of -472 nT; the strongest of the current solar cycle. To understand the factors that led to

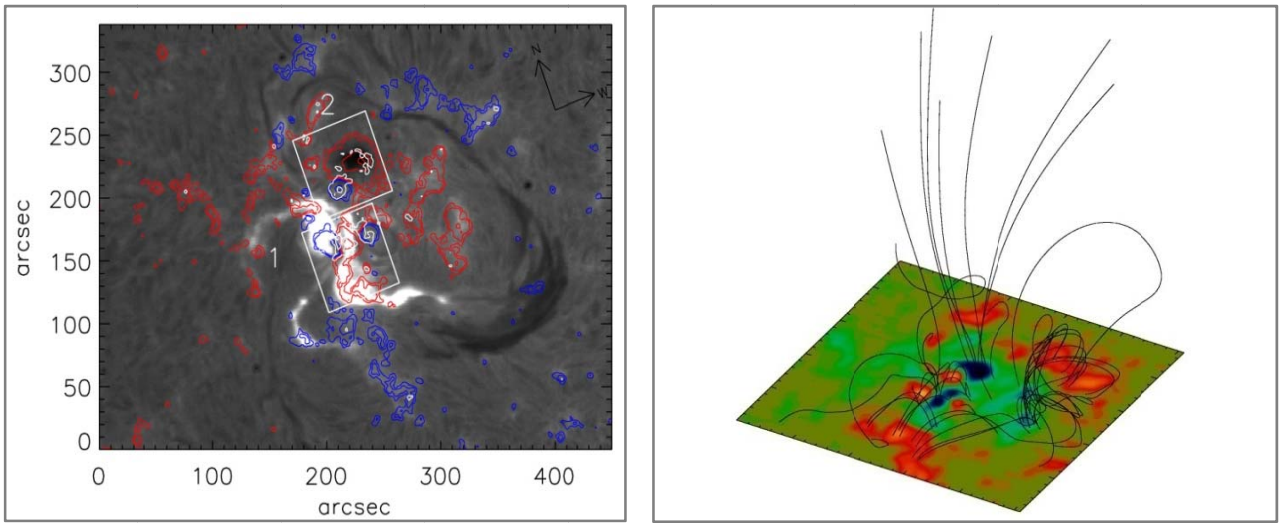


Figure 22 : Overlay of H-alpha image obtained from the Udaipur Solar Observatory of the source active region of the CME of November 18, 2003, and MDI line-of-sight magnetic field contours, where the red and blue contours denote the positive and negative polarities, respectively. The white contours are the locations of strong magnetic field gradient (Left Panel). The non-linear extrapolated magnetic field lines in the NOAA AR 10501 obtained from the vector magnetogram data on 18 November at 00:20 UT from the Solar Flare telescope at Mitaka, (Right Panel).

this CME, the evolution of the photospheric magnetic field of NOAA AR 10501, the source region of the CME, was examined. Quantitative estimates of variation in magnetic flux, energy and magnetic field gradient for the source active region were obtained. Chromospheric images region in Hα from Udaipur Solar Observatory were also used to compare the flare location with regions of varying magnetic flux and gradient (Figure 22, Left panel). The non-linear force-free field line extrapolation indicated that the region of the flare/CME onset was marked by twisted non-potential low-lying field lines as compared to other regions (Figure 22, Right Panel).

This work was done in collaboration with Thomas Wiegelmann of the Max Planck Institute for Solar system Research, Germany.

(Nandita Srivastava, Shibu K. Mathew and Rohan E. Louis)

3-D Reconstruction of Leading Front of Coronal Mass Ejections observed by COR1/SECCHI Coronagraphs on STEREO Spacecrafts

New data from the Solar TErrestrial RElations Observatory (STEREO) launched in October 2006 provide stereoscopic images of the Sun's atmosphere. The two STEREO spacecrafts, A and B, orbit the Sun at approximately 1 AU near the ecliptic plane with a slowly increasing angle of about 45°/year between them. Stereoscopic images from the "Sun Earth Connection Coronal and Heliospheric Investigation" (SECCHI) aboard STEREO helped determine the location of a CME in 3D space and in the derivation of its true direction of propagation. We reconstructed the leading front of coronal mass ejections of May 20, 2007, observed by SECCHI coronagraphs aboard STEREO A and B spacecrafts

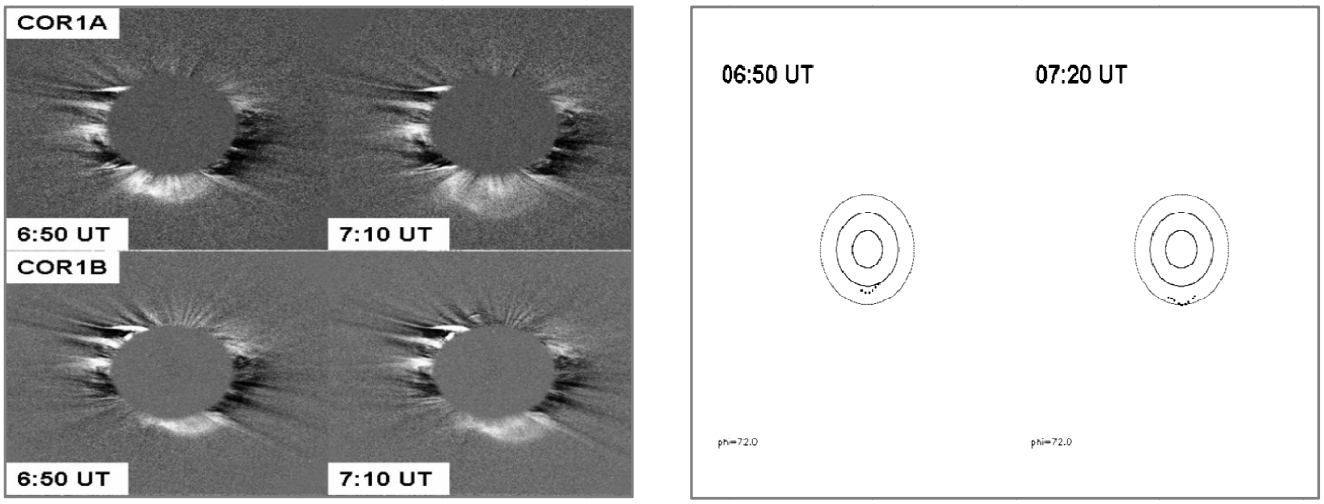


Figure 23 : SECCHI COR1 coronagraph image of the corona in white light from 1.4 to 4 solar radii (left panel). The upper and lowerpanels show coronal mass ejection observed on May 20 , 2007, by the COR1A (Ahead) and COR1B (Behind) respectively, on STEREO spacecrafts. Time evolution of the leading fronts of the CME of May 20, 2007. (Right panel).

(Figure 23, left panel). For the reconstruction, the two methods used were the tie-pointing (based on epipolar geometry) and the height-time methods. Both the methods were applied to the CME images from COR1 A and B

coronagraphs. The reconstructed front is plotted in Figure 23, right panel. The true speed derived from the reconstruction of the leading edge was estimated to be approximately 470 km s^{-1}; close to the measured in-situ solar wind speed at 1 AU. In contrast, the projected plane-of-sky speed of the leading edge of the CME was much lower, around 230 km s^{-1}, estimated from LASCO on SoHO as well as from STEREO A and B images. Our result provides a better estimation of the true speed of the CME in the sun-earth direction and therefore has an important bearing on space weather prediction.

This work was done in collaboration with Marilena Mierla and Bernd Inhester at the Max-Planck Institute for Solar System Research, Germany.

(Nandita Srivastava)

Spectral Characterization of NOAA 8242 in Quiet and Sunspot Regions

We analysed simultaneous Stokes profiles of Fe I twin lines at 6302 Å and CaII K line at 3934 Å over NOAA AR 8242 observed using Advanced Stokes Polarimeter (ASP) instrument of the Vacuum Tower Telescope (VTT) of National Solar Observatory, Sac Peak, USA on June 13, 1998. Along with the spectral data, simultaneous filtergrams were also obtained in G-Band (~ 4300Å), H-alpha 6562.8Å and continuum at 6118.7 Å. Spectral data corrected for various solar and non-solar effects was used to construct spectroheliograms and maps of asymmetry, velocity, full-width at half maximum, and equivalent widths. These maps were constructed by a Gaussian fit to spectral line profiles in quiet and sunspot regions. An Overall increase in asymmetry in the line profiles was found over sunspot regions. This was attributed to velocity and magnetic field gradients. Further, the asymmetry pattern for the two Fe lines did not match in the sunspot regions due to different Lande g-factors of the lines. Velocity maps showed the usual Evershed flows; red shifted in the limb-side and blue shifted in the red-side penumbra.

This work was done in collaboration with Vaibhav Janve of IIT, Kharagpur.

(Ashok Ambastha)

Damping of Alfvén Waves Propagating in the North Polar Coronal Hole Plasma

It is well known that Alfvén waves are incompressible in a uniform or slowly varying medium (where wavelength of waves is less than the characteristic scale length of the medium). Earlier workers have considered compressive viscosity as a damping mechanism to dissipate Alfvén waves. This is inconsistent with the Alfvénic dissipation which essentially requires shear viscosity. We demonstrated that the choice of compressive viscosity was incompatible with their final dispersion relation, and lead to unphysical results, e.g., the group velocity becoming comparable to velocity of light in vacuum. Thus, the formation of plateau in the non-thermal velocity profile of Si VIII, (as seen by SUMER) remain unexplained. Furthermore, the heating rate associated with the unrealistic wave damping is 4 to 5 orders of magnitude larger than the required heating rate.

This work is in collaboration with B.N. Dwivedi of Banaras Hindu University.

(V.S. Pandey and P. Venkatakrishnan)

Longitudinally Propagating Slow MHD Waves in North Polar Coronal Holes

Considering viscosity, thermal conductivity and optically thin radiation as damping mechanisms, propagation of slow magnetohydrodynamic (MHD) progressive waves along the inner part of North Polar Coronal Holes (NPCH) ranging from 1.05-1.35R_o was examined. It was found that in the inner zone of NPCH, ion collision time varied from 1-300s. Consequently, the choice of high frequency waves is restricted to periodicities less than 1s. It was seen that the radial profile of the energy flux of slow mode waves had a decreasing pattern in the considered regime of NPCH. On the other hand, the thermal mode waves indicated an increase until about 1.15R_o, followed by a phase of decline there after. We use these results of thermal mode waves to explain the plateau formation in the radial profile of the non-thermal line-of-sight velocity of Si VIII observed by SUMER.

This work is in collaboration with A. Satya Narayanan of the Indian Institute of Astrophysics.

(V.S. Pandey and P. Venkatakrishnan)

Optical Design of Space based Coronagraph (Aditya)

"Aditya" is a multi-institutional project for a space based coronagraph intended to study the solar corona. USO contributed to the optical design of the instrument. Theoretical studies and simulations were performed to compare the externally occulted coronagraph with an internally occulted one. In the case of externally occulted coronagraphs, the required boom length, diameter of the external occulter, vignetting caused by the occulting disc and its subsequent effect on the resolution were studied. These were validated with existing externally occulted coronagraphs, LASCO-C2 and C3. In the case of internally occulted coronagraphs, preliminary calculations were performed to study the amount of scattered light due to micro-roughness of the primary mirror. Based on the above studies, it was decided to design and develop an internally

occulted coronagraph. After several iterations, the optical design of the proposed system could be optimized to achieve the primary goals of the project (Figure 24).

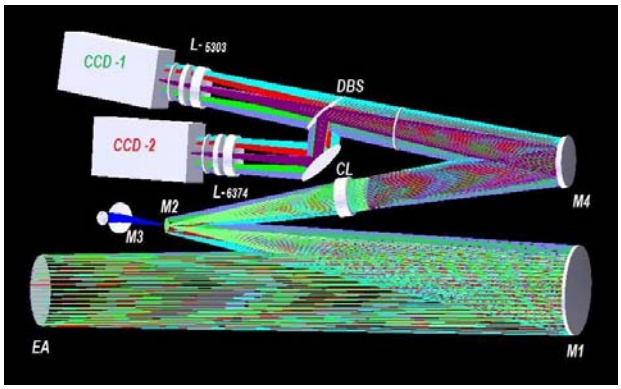


Figure 24: Optical Layout of the space board coronograph "Aditya". Primary mirror focal length is 1.3m; Entrance aperture diameter is 18 cm. It includes 2 off-axis parabolic mirrors (OAP mirrors), one folding mirror, two lenses (L-5303 and L-6374), one collimating lens (doublet). The overall dimension of the system is 1.75 m × 0.85 m × 0. 35 m.

This work is being carried out in collaboration with Jagdev Singh and B. Raghavendra Prasad of the Indian Institute of Astrophysics and K. Sankarasubramanian of Indian Satellite Centre.

(A. Raja Bayanna, Shibu K Mathew and P.Venkatakrishnan)

A Dual Beam H-alpha Doppler System

Many coronal mass ejections (CMEs) are associated with erupting prominences (EPs). To better understand these phenomena, it is not only sufficient to have plane-of-sky velocity observations of prominences, but also to have line-of-sight velocity measurements. To achieve this, a dual

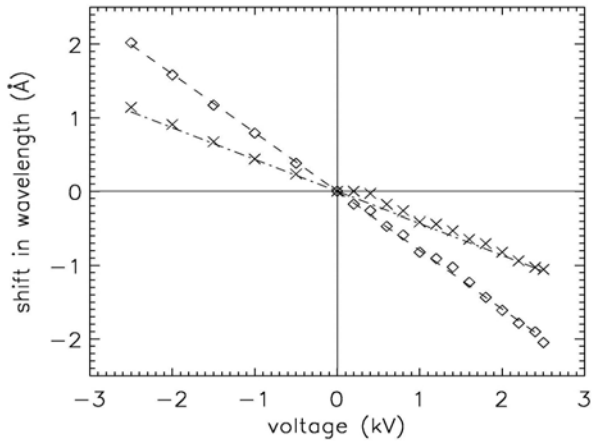


Figure 25: Shift in centre-wavelength of ordinary (dashed line) and extraordinary (dot-dashed line) channels of the Lithium-Niobate FP etalon with increasing high voltage.

beam H-alpha Doppler system is being developed at USO that would monitor activity status of filaments, and measure their line-of-sight velocities during eruption. This instrument would measure the Doppler shifts in H-alpha line for the EPs for velocities in the range of -150 to +150 km/s. A 0.1 Å pass-band Fabry-Perot (FP) etalon with $LiNbO_3$ wafer along with a 1 Å pre-filter are the main components of the instrument. The FP will be tuned to the desired wavelength in H-alpha wings by applying voltages in the range of -2500 V to +2500 V. (Figure 25) shows that the ordinary (o) channel of the FP is more sensitive (-0.80 mÅ/V) to a voltage change than the extraordinary (e) channel (-0.43 mÅ/V). Therefore, the o channel will be used for Doppler measurements. The operating temperature of the FP is set at 43°C. A 6-inch objective and other auxiliary optical components will feed the sunlight to the instrument. It is expected that the instrument will be ready for observations by December, 2008.

(Anand D. Joshi, Shibu K. Mathew, Nandita Srivastava, Sudhir K. Gupta)

A constant temperature oven for Lithium Niobate Fabry-Perot etalon

We developed a temperature stabilized oven for Lithium Niobate Fabry-Perot etalon for use with a new Hα Doppler system to measure line-of-sight velocities in solar filaments. The oven temperature can be set between 30 and 50°C with an accuracy of ±0.0625°C. A 12-bit digital sensor DS620 from Dallas Semiconductors is used to measure the temperature. Pulse Width Modulation (PWM) technique is used for controlling the heater current. The control software reads the sensor temperature and generates an appropriate pulse width signal which is then fed to a current amplifier and subsequently to the heater. (Figure 26) shows one of the test runs of the oven before installing the etalon with the temperature set at 45°C, and the initial temperature of the oven around 30°C. Within 15 minutes of switching on the heater supply, the temperature reached the set value of 45°C and remained within ± 0.0625°C around it through out the run.

(Sudhir Kumar Gupta, Shibu K. Mathew, Anand D. Joshi and Nandita Srivastava)

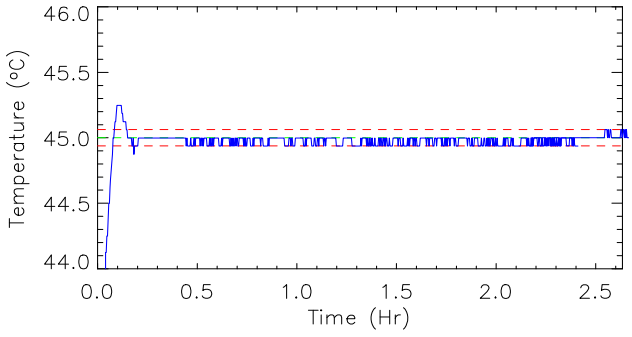


Figure 26: Test run showing stability of ± 0.0625°C, at a set temperature of 45°C throughout the 2.5 hour long run.

A Photo-Cell Based Telescope Guidance System for the Coude Telescope

Any misalignment in a telescope's polar axis results in improper sidereal tracking. At USO, we developed a guider

mechanism that senses the errors using a set of 4 photo-cells with each pair placed in an orthogonal direction. A 3.2 cm full disk image of the Sun is formed on these photo-cells which generate voltages in the two orthogonal directions. The error signals are in turn suitably amplified and fed to two respective DC motors operating in a closed-loop. This setup allows offset-guiding by which the telescope can track features located away from the centre of the Sun. The solar image motion was estimated using a 2-D cross correlation algorithm by taking the first image of the time series (obtained in the science camera) as the reference. The performance of the guider in the ON and OFF mode is shown in the (Figure 27).

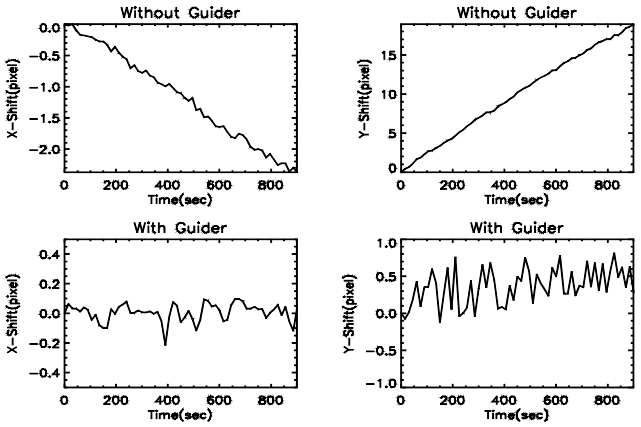


Figure 27: Perfomance of photo-cell bssed telescope guidance system. Top panels show the image motion in X and Y direction. Bottom panels show the image motion in X and Y direction with the guider turned ON.

(Sudhir Kumar Gupta, A. Raja Bayanna, Rohan E. Louis and Shibu K. Mathew)

Space and Atmospheric Sciences

The Space and Atmospheric Sciences Division is engaged in the research related to atmospheres of Earth and other planets. The emphasis is on the study of the changes occuring in the arth's atmosphere due to natural and anthropogenic processes. These studies involve measurements of various parameters using state of the art techniques as well as modeling.

Aerosol Properties in Indian Urban Areas

Inter and intra-annual variations in the aerosol optical depths (AOD) and fine mode fraction (FMF) were estimated using MODIS (Moderate Resolution Imaging Spectroradiometer) data for 2001-2005 over four urban areas in India - Chennai, Mumbai, Kolkata, and New Delhi. Monthly mean 550 nm AODs were higher than 0.30 over all the four locations and had prominent seasonal variations with summer highs and winter lows (Figure 28). FMF values were low during pre-monsoon and summer over Chennai, Mumbai, and New Delhi, while they were 0.9 or higher over Kolkata during the entire year. The data suggest that strong convection in summer is accompanied by a deeper boundary layer, which results in a hygroscopic growth of fine mode, water soluble aerosols leading to higher AODs during summer. Upto 94% of the FMFs in the 0.8-1.0 range

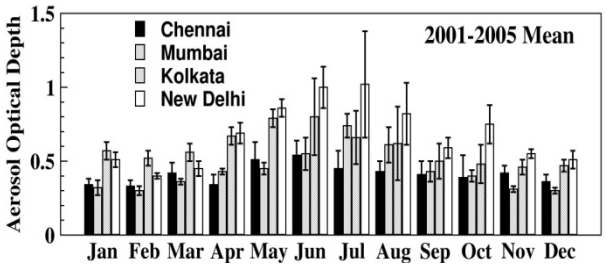


Figure 28: Monthly mean 550 nm MODIS aerosol optical depths at 550 nm obtained by averaging the data from 2001 to 2005 over (a) Chennai, (b) Mumbai, (c) Kolkata, and (d) New Delhi. Vertical bars indicate ±1σ from the mean.

contribute to the frequency distribution in Kolkata suggesting the dominance of fine mode aerosols throughout the year.

(S. Ramachandran)

Aerosol Radiative Forcing Estimates Over Bay of Bengal and Arabian Sea

During an integrated campaign in the pre-monsoon season, aerosol optical depths (AOD) at six wavelengths, mass concentrations, and aerosol chemical composition were measured simultaneously onboard a cruise over Bay of Bengal and Arabian Sea. The data were utilized to estimate

aerosol radiative forcing. AODs for a large number of wavelengths, single scattering albedo values, and asymmetry parameters were estimated using an optical aerosol model. These were also used as inputs in the radiative transfer model to calculate shortwave aerosol radiative forcing. The mean aerosol radiative forcing at the surface over Bay of Bengal and Arbian Sea are found to be over 22 Wm^{-2} and 15 Wm^{-2}, respectively. The atmospheric warming is a factor of two higher over Bay of Bengal (10 Wm^{-2}) as compared to that over Arabian Sea. It is inferred that a higher columnar concentration of aerosols combined with a lower single scattering albedo values give rise to higher aerosol radiative forcing over Bay of Bengal.

(Sumita Kedia and S. Ramachandran)

Study of MODIS Derived Aerosol Optical Depth Over Western India

The Rann of Kuchchh in the western Indian state of Gujarat is an area that highly reflects salt deposits and thus provides a test case for the study of MODIS algorithms. For this purpose, the MODIS derived aerosol optical depths for the period 2002-2005 from the Collection Version C005 and Deep Blue Algorithm were averaged over 0.5 degrees to derive the aerosol optical depth map for the region. It is found that this algorithm fills in the gaps in the conventional aerosol product. A comparison of AOD from Version C005 with ground based sun photometer data over Ahmedabad shows a considerable improvement over previous MODIS algorithm. This comparison has the best correlation during pre-monsoon (April to May) and least correlation during the dry season (December to March).

(Amit Misra and A. Jayaraman)

Aerosol Characteristics over Urban and Pristine Regions

Aerosol characteristics such as aerosol optical depth (AOD), total and black carbon mass concentration, aerosol size distribution and scattering coefficients from two selected locations (one an urban region, Ahmedabad (23.03°N, 72.5°E), and the other a hill station Mount Abu (24.65°N, 72.78°E), at 1.7 km altitude) were studied. AODs were measured simultaneously in five different narrow wavelength bands centered at 0.38, 0.44, 0.50, 0.67, and 0.87 μm using Microtop Sun photometers. Over Ahmedabad, AOD (at 0.50 μm) was minimum (0.27) during monsoon and maximum (0.41) during post-monsoon. Over Mt. Abu, AOD was minimum (0.09) during winter and maximum (0.18) during post-monsoon. Being an urban location, Ahmedabad always has a factor of 2.5 higher AOD than that over Mt. Abu, except during winters when the factor increases to 4, due to high biomass burning.

(S. K. Das and A. Jayaraman)

Seasonal Variation of Mixed Layer Height Over Ahmedabad

Seasonal variation of mixed layer height (MLH) in the morning time at around 0930 hrs over Ahmedabad (23.03ºN, 72.54ºE), was investigated using the altitudinal profiles of meteorological parameters deduced from radio-

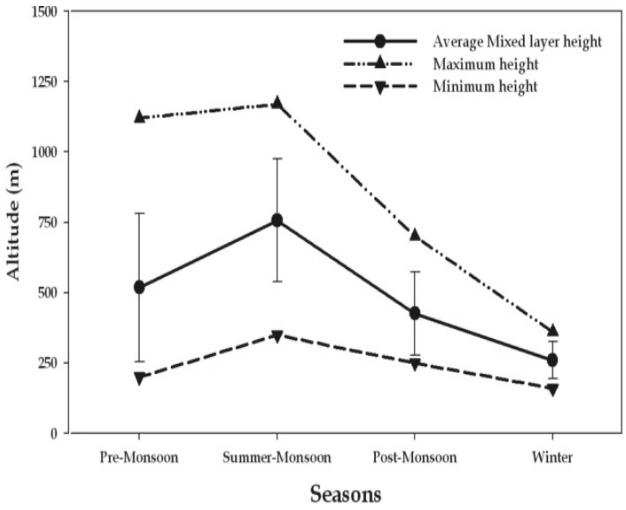


Figure 29: Seasonal variation of the mixed layer height (MLH) observed over Ahmedabad.

sonde data during April 2003 – July 2007. A total of 82 fortnightly balloon flights from Ahmedabad enabled a study of the variation in ozone distribution. The MLH was extracted from the profiles of virtual potential temperature and specific humidity. A systematic seasonal trend was observed in the variation of MLH, showing a progressive decrease from summer to winter months. MLH shows seasonal variation with a maximum (~1170 m) in summer/monsoon and a minimum (~160 m) during the winters (Figure 29). Highly variable mixed layer height is observed during pre-monsoon and summer/monsoon seasons with an average altitude of 518 ± 264 m and 756 ± 217 m. However, this variability is lower in post monsoon and winter seasons with an average height variation of 425 ± 147 m and 260 ± 65 m.

(S. Srivastava, S. Gupta, S. Venkataramani, T. A. Rajesh and S. Lal)

Lidar Observed Stratospheric Sudden Warming (SSW) Over Mount Abu: Evidence of Interaction Between Planetary Wave and Stratospheric Circulation

A spectacular transient phenomenon in the middle atmosphere is the Stratospheric Sudden Warming (SSW). This has been observed mostly over high and mid latitudes. Major warming events during the year 1998-99 were identified and have been investigated using ground based Lidar data collected over Mount Abu. Observed stratospheric temperatures were higher by more than 15 K during the warming event of December 1998. Besides the Lidar data, temperature data from Halogen Occultation

Experiment (HALOE) on board the Upper Atmospheric Research Satellite (UARS), zonal-mean temperature and wind data from NCEP (National Center for Environmental Prediction) reanalysis were used to characterize the processes operative during SSW's.

During the winter of 1999, a SSW event was observed at Mount Abu for five consequitive days. The sequence of temperature profiles revealed the decay process of this warming episode and the age of SSW over Mount Abu was found to be ~ 5 days. Most of these warmings are attributed to increased Planetary Wave (PW) activity and wave breaking. The calculation of Eliassen-Palm (E-P) flux indicated the propagation of PW from the high and mid to low latitudes during this event.

(Som Sharma, S. Lal, Y. B. Acharya and H. Chandra)

Rocket-borne Study of Mesospheric Airglow Emissions

In the mesosphere and the lower thermosphere (MLT) region, several optical emissions namely, the OI 557.7 nm Green line, O_2 Herzberg bands, OH Meinel bands, etc., are produced by chemical reactions between different species that are present in the region. By measuring the vertical and horizontal column integrated emission intensities as a function of altitude from a space borne platform, it is possible to study various physical processes and the chemistry of the species involved in their formation. A rocket-borne multi-wavelength photometer experiment 'ABHA' was developed at PRL to address these issues. The experiment consisted of deploying six forward-looking and four side-looking photometers on-board a rocket. A RH-300 MK-II rocket carrying these ten photometers was successfully launched on 29 January 2008 from TERLS, Trivendrum. The results are being analyzed.

(H. S. S. Sinha, Uma Das, R. N. Misra, A. P. Gohil, M. B. Dadhania, N. Dutt and S. B. Banerjee)

A Case Study of the Response of Equatorial Ionosphere During a Storm Time Substorm

In order to investigate the response of the equatorial ionosphere to geomagnetic storms and substorms, an event was identified. During this event, the base of the F layer (h'F) of the ionosphere over Thumba, a dip equatorial station, moved to unusually high altitudes during 1630 hr to 2130 hr and descended abruptly after this time to return to its normal height by midnight, which is drastically different from the quiet time behaviour. This variation revealed a remarkable similarity with the mean variation of the auroral electrojet (which is one of the substorm indices). The small-scale periodic component (~ 42 min) in the vertical drift that corresponds to the zonal electric field over the dip-equator was coherent with the Y-component of Interplanetary Electric field, which is responsible for the occurrence of the storm. This investigation reveals two different aspects of the zonal electric field perturbations over the dip equator during a storm-time substorm.

This work was done in collaboration with J. H. Sastri, Indian Institute of Astrophysics (IIA), Bangalore and Sudha Ravindran, Space Physics Laboratory (SPL), VSSC, Thiruvananthapuram.

(D. Chakrabarty and R. Sekar)

Equatorial Spread F Structures and Associated Airglow Intensity Variations Observed Over Gadanki During 2003 – 2007

Co-ordinated campaigns to understand the equatorial spread F structures and associated airglow emissions were conducted from Gadanki by operating simultaneously the MST radar in ionospheric mode and by monitoring the thermospheric airglow line emissions (630.0 nm and 777.4 nm) using a narrow-band, multi-wavelength scanning photometer during 2003-2007. The wavelengths of large-scale bottom side modulation associated with the equatorial spread F (ESF) were estimated using these results. In addition, optical signatures were found to be useful in inferring the shears in the zonal plasma drift for the events based on which the confined bottomside structures are explained. Plasma enhancements and active fossil plumes are also identified. It is found that the vertical columnar intensity of 630.0 nm airglow, on occasions, exceeded the slanted columnar intensity in the presence of large bottom side structure.

This work was done in collaboration with A. K. Patra, National Atmospheric Research Laboratory (NARL), Gadanki.

(R. Sekar, D. Chakrabarty and R. Narayanan)

Identification of Stratified Layers in Sodium Airglow

In order to investigate the relationship between the temporal variations of sodium airglow emission and the density of sodium atoms, simultaneous measurements (Figure 30) by a narrow-band airglow photometer and lidar were made from Gadanki during March, 2007. Correlation coefficients between the column-integrated airglow intensity and concentration of neutral sodium atoms as a function of altitude at various time intervals were computed. The analyses revealed that the correlation coefficients are high (> 0.9) at two different altitudes. In addition to that, power spectrum analyses of the detrended altitude profiles of sodium concentration brings out the dominance of wave activities with characteristic vertical scale size of about 9.6 km. This investigation indicates that the stratifications in sodium airglow are probably created by the mesospheric wave activity.

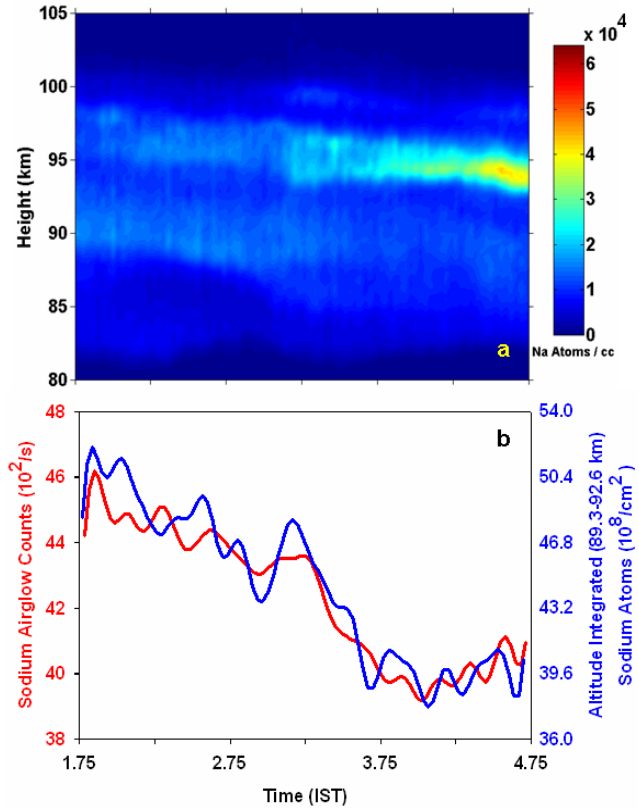


Figure 30: (a) Height-Time-Concentration map of sodium atoms in the mesosphere based on the sodium lidar observations at Gadanki on March 20 2007, (b) Comparison of sodium airglow intensity variation and height- integrated (89-93 km) sodium concentration.

This work was done in collaboration with Y. Bhavani Kumar, National Atmospheric Research Laboratory (NARL), Gadanki.

(R. Sekar, S. Sarkhel, D. Chakrabarty and R. Narayanan)

Anomalous Enhancement Observed in Dayglow Emissions during Space-Weather disturbances

During severe space weather events, different latitudes of the Earth's upper atmosphere receive different amounts of energies. This latitudinal disparity in energies sets up large scale (high- to low-latitude) dynamics in neutral species. Low-latitude ground-based optical daytime thermospheric measurements showed sharp temporal and spatial variations in the emission brightness during a storm. Initial analysis indicates that a latitudinal change in the composition is responsible for such an enhancement in the emission brightness. Detailed analysis is currently in progress to quantify these variations in order to understand the energy inputs to various latitudes during space weather events.

This work is in collaboration with S. Chakrabarti at Boston University, USA, S. Solomon, at University Corporation for Atmospheric Research (UCAR), USA and G. Crowley at Atmospheric and Space Technology Research Associates (ASTRA), USA.

(D. Pallamraju)

Ionospheric Modulations due to Solar Flares Over Ahmedabad

Earth's ionosphere responds quickly to the enhanced X-ray and ultraviolet (UV) radiation emitted from the Sun during solar flares. Regular ionospheric soundings have been made over Ahmedabad (23° N, 72.4° E) using KEL digital ionosonde. Using this data, the influence of the excess X-ray emission from the flares / CMEs in different regions of the Earth's ionosphere over Ahmedabad were examined. Based on the X-ray spectral characteristics of the flares, the variation in the minimum frequency of reflection (f_{min}), an indicator of the ionization in the D-region of the ionosphere, was measured. Excess absorption due to solar flares in the D-region of the ionosphere over Ahmedabad was examined for several events during 1996-2000. Significant positive correlation was seen between the f_{min} (measured by the ionosonde) and measured X-ray flux from the GOES satellite. A case study of an event on 12 May 1997 indicated that the critical frequency of the E layer (f_oE), increased suddenly from 0945 hrs to 1200 hrs. Significant increase (30%) in the E layer electron content was observed during 1000 to 1130 hrs as compared to the control day. The increase is associated with the excess X-ray emission following the solar flare.

(Som Sharma, H Chandra and H. O. Vats)

Model Results of D, E, and F layers in the Martian Ionosphere

An attempt was made to understand the contribution of different sources of ionization for the generation of the daytime Martian ionosphere. In this model, three sources of ionization, viz, solar EUV, (~10-100 nm) X-ray (1-9 nm) and galactic cosmic rays (1-1000 Gev) were considered. It was found that the daytime ionosphere could be divided into D, E, and F layers at altitudes of ~25 km, 100-112 km, and 128

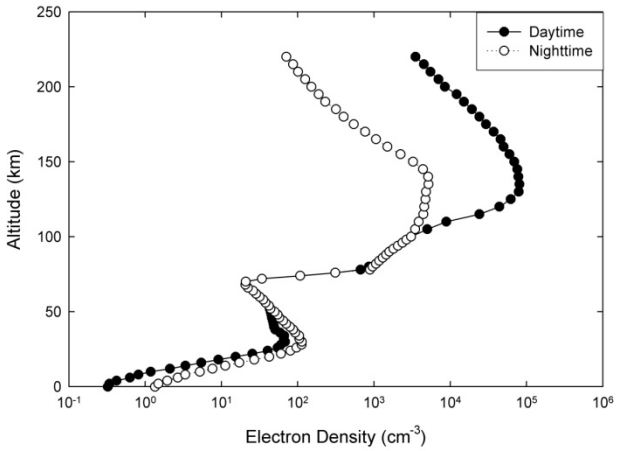


Figure 31: Model estimated vertical profiles of electron density for the Martian ionosphere during the day and the night.

km, respectively, with concentrations of ~1.5x10^2 cm^{-3}, 2.4x10^4 cm^{-3} and ~10^5 cm^{-3}. The nighttime ionosphere

produces D and F peaks at altitudes of 30 km and ~132 km due to galactic cosmic rays and precipitation of solar wind electrons, respectively. The E layer was not clearly visible in the nighttime ionosphere of Mars (Figure 31). The F region peak electron density was larger in the daytime ionosphere as compared to the nighttime by a factor of 20. No significant difference between the day and the nighttime D regions was seen because the incident flux of galactic cosmic rays remained the same. The neutral atmosphere of Mars does not change between the day and the night.

This work was carried out in collaboration with Vikas Singh, Universita' degli Study di Brescia, Italy.

(S.A. Haider)

Troposphere of Mars at High Latitudes: Seasonal Variability

An ion-neutral model is used to calculate production rates, positive and negative ion densities in the Martian troposphere. Temperature and neutral density data obtained from the Mars Global Surveyor radio occultation experiment are used as inputs to this model. It is found that the hydrated hydronium ions $H_3O^+(H_2O)_{2,3}$ and water cluster ions $NO_2^- H_2O$ and $CO_3^-(H_2O)_{1,2}$ are dominant in the Martian troposphere. The densities of these ions vary by a factor of 5-10 between the two hemispheres. The attachment of ions to aerosols is found to be an important loss process. Such charging of aerosols would occur within the dust clouds observed on Mars.

(S.A. Haider, Varun Sheel)

Study of Ion-Aerosol Interaction in the Martian Atmosphere

Aerosols play an important role in the lower ionosphere of Mars. A one-dimensional model has been developed to study the ion-aerosol interaction. The model takes into account various processes like attachment, dissociation, recombination involving ions, electrons, aerosols, and neutrals. Preliminary results show that the ion and electron densities reduce by a few orders of magnitude in the presence of aerosols due to ion-aerosol attachment process.

This work was carried out in collaboration with S. N. Tripathi, I.I.T. Kanpur.

(Varun Sheel and S.A. Haider)

Fragmentation of Molecules by Electron-Impact

Association and migration of atoms due to structural changes in molecular ions formed by electron impact on molecules are studied. Formation of Cl_2^+ from CCl_4, H_2^+ and H_3^+ from alcohols and methane was observed and changes in the structure of the parent molecule that could explain the formation of the observed species were proposed (Figure 32).

(V. Sharma, R. K. Kushawaha and B. Bapat)

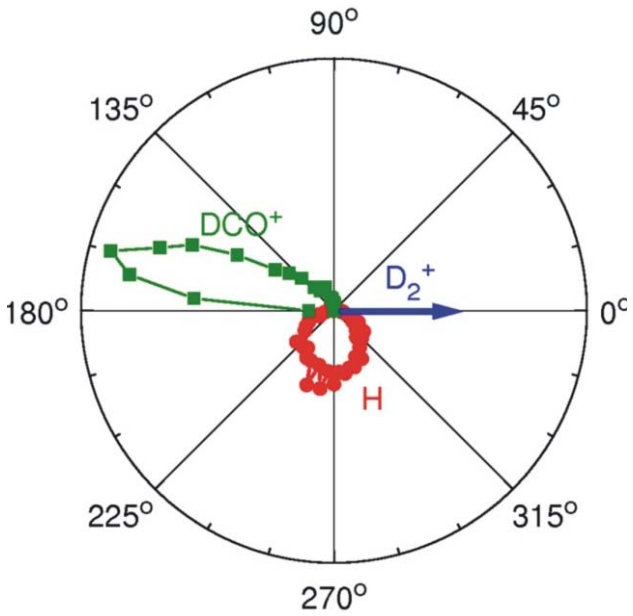


Figure 32: Angular distribution of fragments arising from a three-body break-up of CD_3OH^{2+} (an isotopomer of methyl alcohol). The break-up involves association of two D atoms in the methyl alcohol molecule, which break away from the carbon atom.

Inner Shell Photoionisation of Molecules

To understand the inner-shell ionisation of CO_2 and SF_6 molecules, experiments at the Indus-1 synchrotron were carried out. A portable multi-particle ion momentum spectrometer that could be used for various kinds of collision experiments was built for this purpose. These experiments show that dissociative photo-ionisation of molecules lead to association of certain species. This was seen from the formation of F_2^+ from SF_6. This phenomenon depends on the photon energy.

The project is being carried out in collaboration with P. C. Deshmukh and S. Sunil Kumar, Indian Institute of Technology, Madras and G. S. Lodha, Raja Ramanna Centre of advanced Technology (RRCAT), Indore.

(B. Bapat, R. K. Kushawaha, I. A. Prajapati, and K. P. Subramanian)

Langmuir Probe Studies of Multi-Component Laser Ablated Plasma

The evolution features of ions generated by laser-blow-off (LBO) of multi-component LiF-C target exhibited multi-peak structures in their temporal profiles as recorded by a Langmuir probe. The model for mass dependent expansion velocity to determine the respective peak-positions in the profile accorded well with the experimental data. The

electron temperature of the LBO plume was higher than the electron temperature of laser produced plasma from solids.

The work is being carried out in collaboration with Sunil Kumar, Ajai Kumar and R. K. Singh of The Institute for Plasma Research (IPR), Gandhinagar.

(K.P. Subramanian)

Theoretical Physics

The activities of the theoretical physics division cover a very broad range of areas that include High Energy Physics, Astro-particle physics, Cosmology, Non-linear Dynamics, Atomic and Nuclear Physics and Quantum and Classical Optics. Major activities are in the field of particle physics where basic aim is to carry out theoretical and phenomenological studies of physics beyond standard model. In recent years, there is a considerable emphasis on the study of the inter-disciplinary areas of astro-particle physics and on confronting the available information on the cosmic microwave background radiation with theories of particle physics.

Long Range Leptonic Forces

It was pointed out that neutrino oscillations provide a sensitive probe of the long range leptonic forces that can arise in the minimal gauged extensions of the standard model. Detailed constraints on the strength of such forces using results from the atmospheric and the solar neutrino experiments were earlier worked out. These constraints were used to show that future neutrino beams from nuclear beta decays can be used to search for these forces in detectors such as planned in the Indian Neutrino Observatory (INO).

This work was done in collaboration with S. K. Agarwalla of Harish-Chandra Research Institute, Allahabad

(A. S. Joshipura and S. Mohanty)

Constraining γZH and *ZZH* Couplings at Linear Collider with Polarized Beams

In the standard model, the Higgs bosons have tree-level couplings to a pair of *Z* bosons, but not to a pair of photons or a γZ pair. It is important to investigate the magnitude and form of these couplings to establish the correctness of the standard model and to study effects beyond the standard model. For example, the γZH coupling, if discovered at a level above that predicted by loop effects in the standard model, would signal new physics beyond the standard model. We systematically investigated the constraints that can be obtained at a linear collider with either longitudinally polarized or transversely polarized beams on ZZH and γZH couplings through the process. We demonstrate how simultaneous limits on the different forms of these couplings can be placed with the help of unpolarized and polarized beams. A significant result is that the transverse polarization allows the determination of the absorptive part of the CP-conserving γZH coupling,

independent of other ZZH and γZH couplings.

(S.D. Rindani and P. Sharma)

Charged Lepton Distributions as a Probe of Contact $e^+e^- \to ZH$ Interactions at a Linear Collider with Polarized Beams

$e^+e^- \to ZH$ is an important process for the production of a Higgs boson H at a linear collider. In the standard model, which has a single Higgs boson H, this process proceeds through the exchange of a virtual Z boson. In extensions of the standard model, which could have more than one Higgs boson, the production process may have other contributions. These can all be combined and represented as a general four-point coupling. Individual processes in various models may be obtained as special cases of the four-point coupling. With a view to treating all such new contributions in full generality, we examined general four-point interactions arising from new physics and contributing to the Higgs production process. For this we wrote all possible forms for these interactions consistent with Lorentz invariance, allowing for the possibility of CP violation. Contributions to the process from anomalous ZZH and γZH interactions studied earlier arise as a special case of our four-point amplitude. We considered the decay of Z into a charged lepton pair and obtain expressions for polar and azimuthal angular distributions of charged leptons arising from the interference of the four-point contribution with the standard-model contribution. Possible longitudinal or transverse beam polarization likely to be available at a linear collider were taken into account. We examined several correlations which could be used to study the various form factors present in the contact interactions. We also obtained the sensitivity of these correlations in constraining the new-physics interactions at a linear collider operating at a centre-of-mass energy of 500 GeV with longitudinal or transverse polarization.

(Kumar Rao and S.D. Rindani)

CP Violation and Neutrinos

CP violation has been observed in the interactions of quarks, but it is still not known, if CP violation or matter-antimatter asymmetry is present in the interactions of the leptons. Since both the charged (e.g. electrons) and the neutral leptons (neutrinos) take part in weak interactions, studies of neutrinos are also expected to inform on possible CP violation in the interactions of the leptons. For a better understanding of the problem, we constructed rephasing invariant measures of CP violation with elements of the neutrino mass matrix. This permits a basis independent study of the problem of CP violation in the leptonic sector from our knowledge of the neutrino mass matrix.

(S. Singh and U. Sarkar)

Dark Energy and Pseudo-Nambu–Goldstone Bosons

It is now established that our universe is flat and accelerating, and hence, it is dominated by the cosmological constant or the dark energy. This poses serious problems to theories of particle physics. One possible solution to this problem requires an introduction of a scalar field, whose values would contribute to the dark energy. We provided a natural origin of this field in a model of dynamical neutrino masses via the see-saw mechanism. In this model there are pseudo-Nambu–Goldstone bosons (pNGB), associated with the formation of the heavy right-handed Majorana masses, which naturally acquire soft masses at loop level. These pNGBs can have cosmological implications through mass varying neutrinos, long range forces, and provide a soft potential for dark energy.

This work was done in collaboration with Profs. C.T. Hill from Fermi National Laboratory, USA, I. Mocioiu from Pennsylvania state University, USA and E.A. Paschos from Dortmund University, Germany.

(U. Sarkar)

Scalar-Pseudoscalar Mixing, (semi-) Leptonic B-decays and CP Phase in B(s) Mixing

Recent observations suggest a large, CP violating phase beyond the Standard Model, in the B(s) mixing. There are other indications of possible non-standard effects in hadronic b → s transitions, both in rates and CP and angular variables. A two Higgs doublet model with scalar-pseudoscalar mixing at the tree level may yield appropriate values to simultaneously explain many of the puzzling features in b → s transitions. This requires a careful consistency check for as many decay modes and as many observables. We are exploring this possibility in detail with the aim of providing definite and testable predictions.

(A. S. Joshipura, B. P. Kodrani, N. Mahajan)

Exclusive semi-Leptonic B-decays, Angular Asymmetries and Right-handed Currents

Stringent constraints on theoretical parameters can be obtained by studying the exclusive semi-leptonic B-meson decays, and by further imposing the constraints from inclusive channels. We are exploring the impact of right-handed currents in a model independent way by looking at the forward-backward asymmetry and other angular asymmetries in such decays, in view of their being the focus of the forthcoming LHCb experiment. The intricate interplay of different form factors in the exclusive decays leads to stronger constraints. At the same time, we have found solutions which are identical within errors, to the standard model solution, even for many of the angular asymmetries. If such a pattern persists, full angular fit will

be necessary to clarify the situation.

This work is being done in collaboration with George W.S.Hou (National Taiwan University, Taiwan) and A. Hovannisyan (University of Karlsruhe, Germany).

(N. Mahajan)

Collider Study of the Dark Scalar Doublet Model

In the Standard Model (SM), inclusion of a second scalar doublet (odd under an unbroken Z_2 discrete symmetry), can lead to interesting consequences. Because of the postulated Z_2 symmetry, either H_0 or A_0 must be stable, providing a new source of dark matter candidate. However, the scenario with H_0 being the sole source of dark matter is highly constrained. Consequently it can be plausibly suggested that there could be other sources of dark matter. Since all these new scalars carry a Z_2 odd quantum number, they cannot be produced singly at the collider. These new scalars only couple to the Higgs boson and the electroweak gauge bosons (W, Z) of the SM. Currently, we are searching for the signature of this dark Higgs model at Tevatron Run II. It is worth noting that the soft breaking of the exact Z_2 symmetry in the Higgs potential modifies the Higgs phenomenology considerably. This may have important consequences in the context of B meson decays.

(D. Ghosh, A. Joshipura, N. Mahajan and S. D. Rindani)

Neutron Star with a Hyperon Core

Effect of rotation on the global properties of neutron stars with hyperon core was studied using an effective chiral model. A mean field theory approach with varying nucleon mass was used for this purpose. Resulting gross properties of rotating stars were then compared with the other theoretical predictions and with recent observations from neutron stars. The model predicts the mass of the stars in the range 1.4-2.4 solar mass at Keplar frequency. This is consistent with recent observation of high mass stars.

The Bardeen-Cooper-Schtriffer -Bose Einsten Condensation (BCS-BEC) cross over for relativistic systems was investigated using a variational construct for the ground state and minimization of the thermodynamic potential in a four Fermion point interaction model relevant for quark matter. It was shown that antiparticle degrees of freedom play an important role in the BCS-BEC cross over physics even when the ratio of local momentum to the mass is small. We also discuss the pairing state with an asymmetry in number density. Within the ansatz, thermodynamically stable gapless modes for both fermions and anti-fermions are seen for strong coupling in the BEC regime.

The pairing mechanism of fermions with mismatch in their momentum due to a mass asymmetry in cold fermionic atomic systems was examined. Using a variational ansatz for the ground state, we also probed the BCS–BEC crossover of this system. It was shown that the breached pairing solution with a single local surface was stable. The temperature effects on the fermion pairing within an approximation that is valid for temperatures below the critical temperatures were also examined.

(H. Mishra)

BCS BEC Crossover in Quark Matter

Although quark matter at very high baryon densities is expected to be in a superconducting state due to color interaction, the situation is not so clear at densities relevant for the interior of neutron star. This is due to the fact that the strong coupling dynamics is unclear in this regime of densities. As the coupling increases, the coherence length of the cooper pair of the quarks starts decreasing and can become of the order of inter-particle separation. Under these conditions, it is appropriate to describe the cooper pairs as a localized bound state. At lower temperature, the ground state of such diquark molecule can be a Bose condensate. Although some mean field calculations have been done to describe such BCS BEC cross over in relativistic systems, clearly quantum effects arising from fluctuations of the condensate fields will be important near the unitary regime. A variational approach to take of the fluctuations of the condensate is being investigated.

This work is being done in collaboration with A. Mishra (I.I.T. Delhi).

(H. Mishra, B. Chatterjee)

Phase Glass in Coupled Dynamical Systems

A lattice of oscillators was considered and constrained to choose some of the interactions to favor synchronization of one type while the others to favor synchronization of a different type. This leads to frustration in the ordering of the dynamical variables. We get a phenomenon similar to the spin glass and depending upon the relevant variables, we call the state of the oscillators as a phase glass or a generalized glass. There is a definite ordering of the variables even though the individual variables continue to evolve dynamically, either regularly or chaotically. We introduce a time average order parameter and study the properties of this phase glass.

(R. E. Amritkar)

Deformed Shell Model (DSM) For T = ½ Bands in ^{51}Mn

Deformed, configuration mixing shell model based on Hartree-Fock states with three particle isospin T projection (called DSMT) was applied, along with the *pf* shell GXPF1 interaction, for a study of the structure of the collective

bands in N = Z+1 nucleus ^{51}Mn. The calculations were performed by including large number (127) of deformed configurations. The yrast, yrare and high *J* non-yrast levels compare well with experiment including *E*2 and *M1* transition strengths. Future applications of DSMT will be in the analysis of heavier (A > 62) N = Z and N = Z+1 nuclei which exhibit varied deformation characteristics. With larger shell model spaces needed here, conventional diagonalization is impossible.

This work was in collaboration with S. Mishra and R. Sahu (Berhampur University).

(V.K.B. Kota)

Deformed Shell Model Results for Beta Decay and Double Beta Decay Half Lives

Deformed shell model (DSM) is used as a nuclear structure model to calculate β^+/EC (electron capture) half lives in a number of medium heavy N ~ Z nuclei with mass number A $\geq$ 64. The *N* = *Z* nuclei are the waiting point nuclei for rapid proton capture process. We have used the modified Kuo effective interaction with ^{56}Ni as the inert core. Our results compare well with the predictions of the calculations with Skyrme force. There are now efforts to detect positron double beta decay by more sensitive measurements and ^{78}Kr is one of the candidates in this search. As DSM is well suited for this nucleus, we calculated its positron double beta decay half life. In our calculations for ^{78}Kr, ^{78}Br and ^{78}Se, we used the modified Kuo interaction. Our results are close to that of the QRPA model.

This work was done in collaboration with S. Mishra and R. Sahu, (Berhampur University).

(V.K.B. Kota and A. Shukla)

Power Spectrum Analysis of the Average-Fluctuation Density Separation: Interacting Particle Systems

A sharp separation between spectral averages and fluctuations, as seen in the normal mode decomposition of the density of states for interacting many-particle systems, is essential for the applicability of statistical spectroscopy in which one primarily deals with the averages. The Embedded Gaussian Orthogonal Ensemble of two-body interactions [EGOE(2), representing Hamiltonians for both the fermion and boson systems], provides a theoretical framework for the study of this separation. The power spectrum analysis (introduced by Leclair and emphasized by others in terms of 1/*f*-noise signature of quantum chaos), was used to investigate the nature of the average-fluctuation separation in embedded two-body ensembles in the presence of a mean field, for both fermion and boson systems and in the nuclear shell model. The statistic $\Lambda = (1 - F) \times 100$ where *F* is the false alarm probability shows that the optimized Gram-Charlier expansion up to order 4-6 provides an accurate representation of the smooth density. Addition of higher-order terms changes very little indicating a well defined separation between the average density and its fluctuations.

This work was done in collaboration with R.J. Leclair and R.U. Haq (Sudbury, Canada) and N.D. Chavda (Nirma University, Ahmedabad).

(V.K.B. Kota)

Spectral Distribution Analysis of Random Interactions with Angular Momentum J-symmetry

Spectral distribution theory, based on average-fluctuation separation and trace propagation was applied for the analysis of some properties of a system of *m* (identical) nucleons in shell model *j*-orbits with random interactions that preserve angular momentum *J*-symmetry. Employing the bivariate Gaussian form with Edgeworth corrections for fixed *E* (energy) and *M* (J_z eigenvalue) density of states $\rho(E,M)$, analytical results, in the form of expansions to order $[J(J+1)]^2$, were derived for energy centroids $E_c(m,J)$ and spectral variances $\sigma^2(m,J)$. These were extended for occupation probabilities and expectation values of the pairing Hamiltonian over fixed - *J* spaces. Structure of energy centroids, distribution of widths, probability for centroids with *J = 0* to be lowest, magnitude of cross correlations etc. for random interactions compared well with those obtained recently using other methods. These results established that the new methods employed recently for analysis of random interactions are equivalent to spectral distribution methods developed by PRL scientists many years back.

(V.K.B. Kota, M. Vyas and K.B.K. Mayya)

BEC in Quartic Confining Potentials

The quartic or quadratic confining potential has emerged as a key ingredient to obtain fast rotating vortices in BEC as well as observation of quantum phase transitions in optical lattices. We calculated the critical temperature T_C of bosons at which normal to BEC transition occurs for the quartic confining potential. Further more, the effect of finite particle number on T_C was evaluated and it was seen that $\Delta T_C / T_C$ is larger in quartic potential compared to the quadratic potential for number of particles < 10^5. Interestingly, the situation is reversed if the number of particles is $\geq 10^5$.

(Sandeep Gautam and Dilip Angom)

Computer Algebraic Approach for Atomic Many-Body Perturbation Calculations

Many-body perturbation theory has a long tradition in studies on the electronic structure of atoms and molecules. Over the years, this theory enabled accurate predictions on a large number of properties, such as correlation energies, hyperfine structures, isotope shifts, polarizabilities, decay rates etc. However for many open-shell atoms and molecules, its application has been hampered by the size and complexity of the perturbation expansions if two or more electrons and/or holes appear in open shells. To overcome these difficulties in dealing with open-shell systems, a computer-algebraic approach was developed. This code facilitates the treatment of second-quantized operators and extended model spaces and, hence, the derivation of perturbation expansions. This approach is based on Wick's theorem and an algebraic representation of the model space functions in order to 'formalize' the derivation. Apart from predicting the electronic structure and properties of atoms and molecules with complex shell structures, such a formal approach might be useful and applicable also for studying the dynamics of quantum systems.

This work was done in collaboration with S. Fritzsche, Institute of Theoretical Physics, Kassel University, Germany.

(Brajesh K. Mani and Dilip Angom)

Core Polarization Effects in Atomic EDM Calculations

The effects of parity and time reversal violating potential, (in particular the tensor-pseudotensor electron nucleus interaction) were studied to establish that selected terms representing the interplay of these effects and the residual Coulomb interaction in the coupled-cluster method are equivalent to the coupled perturbed Hartree-Fock. This was demonstrated for the case of the permanent electric dipole moment of atomic Hg.

This work was done in collaboration with R. K. Chaudhuray, B. P. Das from Indian Institute of Astrophysics, Bangalore and D. Mukherjee from IACS, Kolkatta.

(K. V. P. Latha and Dilip Angom)

Polychromatic Vortex: an Interferometric Investigation

Recently, vortices of white light have gained attention because of their spectral properties. An experimental investigation using interferometry, commonly employed for monochromatic vortices, can be useful to study their properties. We produced a polychromatic vortex and studied its properties using interferometry. We confirmed the charge of the vortex and obtained the position of the vortex for red, green and blue colors, which were different. Polychromatic vortices can be used to communicate intelligence in different wavelengths at a time to replace multiplexers and de-multiplexers in the scheme of optical communication that will use optical vortices as information carriers

(R. P. Singh and V. K. Jaiswal)

Producing Optical Vortices through Forked Holographic Grating: Study of Polarization

It is not clear as to what happens to the polarization of the incident light that is transformed into an optical vortex after diffraction from a phase object such as a forked holographic grating. We examined this with optical vortices produced through a computer generated hologram (CGH) by changing the polarization of the incident TEM_{00} mode of a He-Ne laser beam and for first time we could demonstrate that the forked holographic grating changes the polarization in the process of forming the vortex. The changes in polarization were analyzed with the help of Mueller matrices.

This work was done in collaboration with Prof. R. Simon from The Institute of Mathematical Sciences, Chennai.

(V. K. Jaiswal and R. P. Singh)

Critical Coupling at Oblique Incidence

At critical coupling, a nano-layer absorbs almost all the incident energy so that transmission and reflection are suppressed. Previous studies on critical coupling involving absorbing nano-layers were restricted to normal incidence of plane polarized light. We examined critical coupling at oblique incidence and demonstrated that the suppression of both reflection and transmission occurs in a multilayered system with a two-component metal–dielectric composite film as the top layer. It was shown that almost total absorption of the incident electromagnetic energy in the composite film can occur for both TE and TM polarization of the incident light. Moreover, the scattering profiles for the TM polarization exhibit additional resonances, which can be ascribed to the excitation of the bulk plasmons in the composite film.

This work was done in collaboration with Mr. Shourya Dutta Gupta (IIT, Kanpur) and Prof. S. Dutta Gupta (University of Hyderabad).

(Subimal Deb and J. Banerji)

Time-Frequency Analysis of Wave Packet Fractional Revivals

We show that a wavelet based time–frequency analysis of the autocorrelation function is in many ways a more appropriate tool to resolve fractional revivals of a wave

packet than the widely used method of time-domain analysis. Our calculations are based on the model example of fractional revivals in a Rydberg wave packet of circular states. We demonstrate the usefulness of the time-frequency analysis in reconstructing the initial state of a wave packet when its coherent structure is short-lived and decays before it is fully revived. We also explain, both analytically and numerically how fractional revivals manifest themselves in the time-frequency plane.

(Suranjana Ghosh and J. Banerji)

Exploring Fractional Revivals and Sub-Planck Structures in Phase Space with Wigner and Kirkwood

The nonlinear evolution of certain quantum systems such as a Gaussian wave packet in an infinite potential well, can lead to fractional revivals of the initial wave packet. Analogously, a coherent state propagating through a Kerr medium can form the so-called Schrödinger cats and cat-like states. Recently, it was shown that a superposition of Schrödinger cats could give rise to sub-Planck structures (less than ħ in size) in the Wigner distribution. Moreover, it was argued that these ripples in phase space are not spurious and can even be used to measure very weak perturbations.

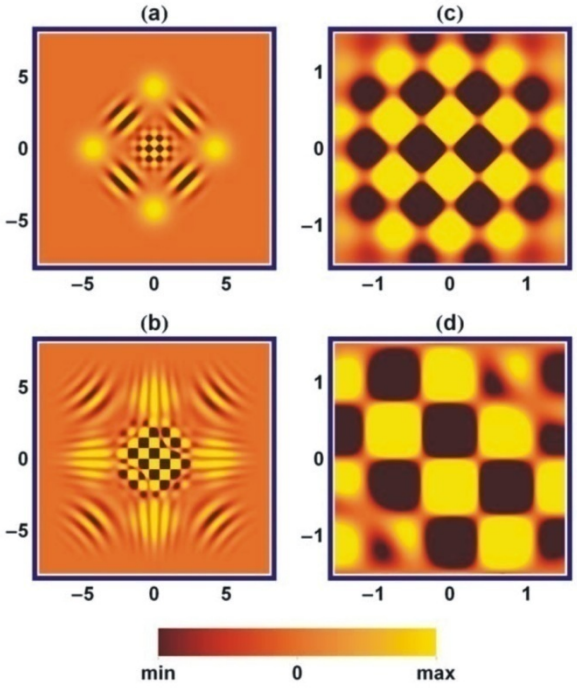


Figure 33: Contour plot of (a) the Wigner and (b) the KR distributions for a cat-like state with a superposition of four coherent states. The state is formed when an initial coherent state $\left|\alpha e^{-i\pi/4}\right\rangle$ propagates through a Kerr medium for a certain duration of time. Here α=3. The horizontal and vertical axes represent the position and momentum variables x and $p/\hbar$ respectively. The chess-board patterns at the centre of the Wigner and the KR distributions are shown in figures (c) and (d) respectively. These are sub-Planck structures as the size of each tile is less than $\hbar$.

In the above context, we introduced and applied the Kirkwood–Rihaczek (KR) phase space distribution 'which differs but little from Wigner's' and yet, had remained obscure for decades. It is thus appropriate and timely to see how it compares with the Wigner distribution in analyzing the above phenomena. Detailed study of fractional revivals in phase space reveals that the KR distribution offers an adequate and parallel analysis of sub-Planck structures (Figure 33), their meaning and possible use.

(J. Banerji)

Fiber-Coupled Dual-Mode Waveguide Interferometer With λ/130 Fringe Spacing

We made predictions and measurements of a multimode waveguide interferometer operating in a fibre coupled, "dual-mode" regime With a 1.32 micrometer source, a complete switching cycle of the output beam was produced by a 10.0 nanometer incremental change in the 8.0 micrometer width of the hollow planar mirror waveguide. This equates to a fringe spacing of λ/130 which is an order of magnitude smaller than previously reported results for this form of interferometer. The interferometer will have many sensor and switching applications in nano-technology.

This work was done in collaboration with R. M. Jenkins and A. F. Blockley from QinetiQ, U. K. and A. R. Davies from Royal Holloway, University of London, U. K.

(J. Banerji)

Publications

Publications in Journals

Astronomy and Astrophysics

1. Aggarwal, M., Jain, R., Mishra, A.P., Kulkarni, P.G., Vyas, C., Sharma, R., and Gupta M., 2008, "*X-ray Emission Characteristics of Flares Associated with CMEs",* Journal of Astrophysics and Astronomy, v. 29, p. 195-205.
2. Banerjee, D.P.K., Misselt, K.A., Su, K.Y.L., Ashok, N.M., Smith, P.S., 2007, "*Spitzer Observations of V4332 Sagittarii: Detection of Alumina Dust*", Astrophysical Journal, v. 666, p. L25-L28.
3. Bharti, L., Jain, R., Jaaffrey, S.N.A., 2007, "*Evidence of Magnetoconvection in Sunspot umbral Dots",* Astrophysical Journal, v. 665, p. L79-L82.
4. Bharti, L., Thomas, R., Jain, R., Jaaffrey, S.N.A., and Smartt, R.N., 2007, "*Detection of opposite polarities in a Sunspot light bridge: Evidence of low altitude magnetic reconnection",* MNRAS, v. 376, p. 1291-1295.
5. Chandrasekhar, T., 2007, "*Chord lengths across main belt asteroids from stellar occultations in the near infrared*", Bulletin of Astronomical Society of India, v. 35, p. 155-161.
6. Gupta, M., Jain, R., Trivedi, JOURNAL, and Mishra, A.P., 2008, "*Microflares as Possible Sources for Coronal Heating",* Journal of Astrophysics and Astronomy, v. 29, p. 171-177.
7. Jain, R., Aggarwal, M., and Sharma, R., 2008, "*X-ray Emission from Solar Flares",* Journal of Astrophysics and Astronomy, v. 29, p. 125-145.
8. Janardhan, P., Ananthakrishnan, S., and Balasubramanian, V., 2007, "*Insights Gained from Ground and Space Based Observations of Long lasting Low Density Anomalies at 1 AU*", Asian Journal of Physics, v. 16, p. 209-232.
9. Janardhan, P., Fujiki, K., Sawant, H.S., Kojima, M., Hakamada, K., and Krishnan, R., 2008, "*The Source Regions of Solar Wind Disappearance Events*", Journal of Geophysical Research, v. 113, A03102.
10. Joshi, U.C., Baliyan, K.S., and Ganesh, S., 2007, "*Variability study of blazars with TAUVEX: scope and limitations",* Bulletin of Astronomical Society of India, v. 35, p. 261-269.
11. Manoj, P., Ho, P.T.P., Nagayashi, O., Zhang, Q., Hasegawa, T., Chen, H., Bhatt, H.C., and Ashok, N.M., 2007, "*An evolved disk surrounding the massive main sequence star MWC 297?"* Astrophysical Journal, v. 667, p. L187-L190.

12. Naik, S., Dotani, T., Kawaii, N., Kokubun, M., Morii, M., Mihara, T., Enoto, T., Kawaharada, M., Murakami, T., Nakagawa, Y., Takahashi, H., Terada, Y., and Yoshida, A., 2008, "*Suzaku Observation of the Anomalous X-ray Pulsar CXOU J164710.2-455216*", PASJ, v. 60, p. 237.

13. Ranade, A., Ashok, N.M., Singh, H.P., and Gupta, R., 2007, "*A Near Infrared Stellar Library III: J band Spectra*", Bulletin of Astronomical Society of India, v. 35, p. 359-387.

14. Ranade, A., Singh, H.P., Gupta, R., and Ashok, N.M., 2007, "*A Near Infrared Stellar Library II: K band Spectra*", Bulletin of Astronomical Society of India, v. 35, p. 87-109.

15. Sukanta, P., Mohanty, S., Janardhan, P., and Oscar, S., 2007, "*Prospects for GMRT to Observe Radio Waves from UHE Particles Interacting with the Moon*", Journal of Cosmology and Astroparticle Physics, v. 11, p. 22-38.

16. Terada, Y., Hayashi, T., Ishida, M., Mukai, K., Dotani, T., Okada, S., Nakamura, R., Naik, S., Bamba, A., and Makishima, K., 2008, "*Suzaku Discovery of Non-thermal X-ray Emission from the Rotating Magnetized White Dwarf*", AE Aquarii, PASJ, v. 60, p. 387.

17. Vats, O., 2007, "*Dynamics of Sun and its atmosphere*", Asian Journal of Physics, v. 16, p. 291.

18. Venkataraman, V., and Anandarao, B.G., 2008, "*Infrared spectroscopic study of a selection of AGB and post-AGB stars*", MNRAS, v. 385, p. 1076-1086.

Planetary and Geosciences

19. Bhattacharya, S.K., Pandey, A., and Savarino, J., 2008 « *Determination of intermolecular isotope distribution of ozone by oxidation reaction with silver metal*", Journal of Geophysical Research., v. 113, D03303, doi :10.1029/2006JD008309.

20. Chamyal, L.S., and Juyal, N., 2008, "*Late Quaternary continental studies in parts of India: Implications for monsoon variability*", Journal of Geological Society of India, v. 71, p. 605-623.

21. Das, A., and Krishnaswami, S., 2007, "*Elemental Geochemistry of river sediments from the Deccan Traps, India: Implications to source of elements and their mobility during basalt-water interaction*", Chemical Geology, v. 242, p. 232-254.

22. Das, J.P., and Murty, S.V.S., 2008, *Nitrogen isotopes in chondrules: Signatures of precursors and formation processes*, Current Science, v. 94, p. 485-489.

23. Dutta, K., Bhushan, R., and Somayajulu, B.L.K., 2007, "*Rapid vertical mixing rates in deep waters of the Andaman Basin*", Science of the Total Environment, v. 384, p. 401-408.

24. Galy, V., François, L., France-Lanord, C., Faure, P., Kudrass, H., Palhol, F., and Singh, S.K., 2008, "*C4 plants decline in the Himalayan basin since the Last Glacial Maximum*", Quarternary Science Review, doi:10.1016/j.quascire, v.2008.04.005.

25. Gupta, A., Kale, V. S., Owen, L.A., and Singhvi, A.K., 2007, "*Late Quaternary Bedrock Incision in the Narmada River at Dardi Falls*", Current Science, v. 93, p. 564-585.

26. Hegde, P., Sudheer, A.K., Sarin, M.M., and Manjunatha, B. R., 2007, "*Chemical characteristics of atmospheric aerosols over southwest coast of India*", Atmospheric Environment, v. 41, p. 7751-7766.

27. Kearsley, A.T., Borg, J., Graham, G.A., Burchell, M.J., Cole, M.J., Leroux, H., Bridges, J.C., Hörz, F., Wozniakiewicz, P.J., Bland, P.A., Bradley, J.P., Dai, Z.R., Teslich, N., See, T., Hoppe, P., Heck, P.R., Huth, J., Stadermann, F.J., Floss, C., Marhas, K., Stephan, T., and Leitner, J., 2008, "*Dust from comet Wild* 2: *Interpreting particle size, shape, structure and composition from impact features on the Stardust aluminum foils*", Meteoritics & Planetary Science, v. 43, p. 41-73.

28. Kumar, S., Ramesh, R., Sardesai, S., and Sheshshayee, M.S., 2005, "*Effect of incubation time and substrate concentration on N-uptake rates by phytoplankton in the Bay of Bengal*", Biogeosciences Discussions, v. 2, p. 1331-1352.

29. Marhas, K.K., Hoppe, P., and Ott, U., 2007, "*NanoSIMS studies of Ba isotopic compositions in presolar silicon carbide grains from AGB stars and Supernovae*", Meteoritics & Planetary Science, v. 42, p. 1077-1101.

30. Miranda, J., Balachandran, K.K., Ramesh, R., and Wafar, M.V.M., 2008, "*Nitrification in Kochi backwaters*", Estuarine, coastal and shelf science, v. 78, p. 291-300, doi:10.1016/j.ecss.2007.12.04.

31. Mukul, M., Jaiswal, M., and Singhvi, A.K., 2007, "*Timing of recent out-of-sequence active deformation in the frontal Himalayan wedge: Insights from the Darjiling sub-Himalaya, India*", Geology, v. 35, p. 999-1002.

32. Nainwal, H.C., Chaudhary, M., Rana, N., Negi, Negi, R.S., Juyal, N., and Singhvi, A.K., 2007, "*Chronology of the late Quaternary Glaciations around Badrinath (upper Alaknanda basin): Preliminary Observations*", Current Science, v. 93(1) p. 90-96.

33. Rai, S.K., and Singh, S.K., 2007, "*Temporal variation in Sr and $^{87}Sr/^{86}Sr$ of the Brahmaputra: Implication to annual fluxes and tracking flash flood through chemical and isotope composition*", Geochemistry, Geophysics, Geosystems, v. 8, doi: 10.1029/2007GC001610.

34. Ramesh, R., Sheshshayee, M.S., and Tiwari, M., 2007, "*Significance of $\delta^{15}N$ variations in a sediment core from the equatorial Indian Ocean during the past ~35ka*, "Current Science, v. 93 (6), p. 840-842.

35. Ray, R., Shukla, A.D., Sheth, H.C., Ray, J.S., and others, 2008, "*Great small-scale lithological heteroge-neity in the Precambrian basement of the central Deccan Traps, India: Direct xenolith evidence from dykes*", Gondwana Research, v. 13, p. 375-385.

36. Rengarajan, R., Sarin, M.M., and Sudheer, A.K., 2007 "*Carbonaceous and inorganic species in atmospheric aerosols during wintertime over urban and high-altitude sites in North India*", Journal of Geophysical Research, v. 112, D21307, doi. 10. 1029/ 2006JD008150.

37. Rudraswami, N.G., and Goswami, J.N., 2007, "*26A1 in Chondrules from unequilibrated L chondrites: Onset and duration of chondrule formation in the early solar system,*" Earth and Planetary Science Letters, v. 257, p. 231-244.

38. Sastry, M.D., Nagar, Y.C., Bhushan, B., Mishra, K.P., Singhvi, A.K., 2007, **"***Unusal radiationdose dependent EPR line at g = 2.54 in feldspars: possible evidence of* Fe^{3+} $O^{2-} \leftrightarrow Fe^{2+}O^{-}$ *and exchange coupled* $Fe3^{+}$ *-*$Fe2^{+}$ *-nO-, (Condensed Matter)",* Journal of Physics, v. 20(2), 5224 doi10.188/0953-8984/20/02/025224 .

39. Savarino, J., Bhattacharya, S.K., Morin, S., Baroni, M., Frey, M., and Doussin, J.-F., 2008, "*NO* + O_3*: An oxygen isotope perspective on the reaction dynamics and atmospheric implications for the transfer of the ozone isotopic anomaly",* Journal of Chemical Physics, 128.

40. Sinha, A., Cannariato, K.G., Stott, L.D., Cheng, H., Edwards, R.L., Yadava, M.G., Rameshand, R., Singh, B., 2007, "*A 900 year (600 to 1500 A.D.) Record of the Indian summer monsoon precipitation from the core monsoon zone of India*", Geophysical Research Letters, v. 34, L16707, doi:10.1029/2007GL030431.

41. Sokol, A. K., Bischoff, A., Marhas, K.K., Mezger, K., Zinner, E., 2007, "*Simultaneous accretion of differentiated or metamorphosed asteroidal clasts and chondrules*", Meteoritics & Planetary Science, v. 42, p. 1291-1308.

42. Srivastava, R., Ramesh, R., Prakash, S., Anilkumar, N., and Sudhakar, M., 2007, "*Oxygen isotope and salinity variations in the Indian sector of the Southern Ocean",* Geophysical Research Letters, v. 34, L24603, doi:10.1029/2007GL031790.

43. Stadermann, F.J., Hoppe, P., Floss, C., Heck, P.K., Hörz, F., Huth, J., Kearsley, A.T., Leitner, J., Marhas K.K., McKeegan, K.D., and Stephan, T., 2008, "*Stardust in STARDUST - the C, N, and O isotopic compositions of Wild 2 cometary matter in Al foil impacts*", Meteoritics & Planetary Science, v. 43, p. 299-313.

44. Sudheer, K., and Sarin, M.M., 2008, **"***Carbonaceous aerosols in MABL of Bay of Bengal: Influence of continental outflow",* Atmospheric Environment, v. 42, p. 4089-4100.

45. Wasson, R.J., Juyal, N., Jaiswal, M., Culloch, M., Sarin, M.M., Jain, V., Srivastava, P., and Singhvi, A.K., 2008, **"***The mountain- lowland debate:Deforestation and Sediment transport in the Upper ganges catchment",* Journal of Environmental Management, v. 88 , p. 53-61.

46. Westphal, A.J., Bastien, R.K., Borg, J., Bridges, J., Brownlee, D.E., Burchell, M.J., Cheng, A.F., Clark, B.C., Djouadi, Z., Floss, C., Franchi, I., Gainsforth, Z., Graham, G., Green, S.F., Heck, P.R., Horányi, M., Hoppe, p., Hörz, F. P., Huth, J., Kearsley, A., Leroux, H., Marhas, K., Nakamura-Messenger, K., Sandford, S. A., See, T. H., Standermann, F.J., Teslich, N.E., Tsitrin, S., Warren, J. L., Wozniakiewicz, P.J., and Zolensky, M.E., 2008, "*Discovery of non-random spatial distribution of impacts in the Stardust cometary collector",* Meteoritics & Planetary Science, v. 43, p. 415- 429.

47. Yadava, M.G., and Ramesh, R., 2007, **"***Significant long term periodicities in the proxy record of the Indian monsoon rainfall",* New Astronomy, doi: 10.1016/j. Newast.2007.04.001, v. 12, p. 544-555.

48. Yadava, M.G., Gandhi, N., and Ramesh, R., 2007, "*Estimation of decomposition rate of peat deposits using radiocarbon*", Indian Journal of Geochemistry, v. 22(1), p. 57-64.

49. Yadava, M.G., Ramesh, R., and Pandarinath, K., 2007, "*A positive "amount effect" in the Sahayadri (Western Ghats) rainfall"*, Current Science, v. 93(4) p. 560-564.

Planetary Science and Exploration Programmes

50. Agrawal, P.C., Sreekantan, B.V., and Bhandari, N., 2007, "*Space Astronomy and interplanetary Exploration"*, Current Science, v. 93, No.12, p. 1767-1778.

51. Banerjee, D., and Dewangan, A., 2008, "*Simulation of the cosmic-ray induced dose-rate within a Martian soil profile"*, Radiation Measurements, doi 10.1016/ j.radmeas.2008.02.022.

52. Banerjee, D., and Gasnault, O., 2008, "*Hard-X rays and low-energy gamma-rays from the Moon: Dependence of the continuum on the regolith composition and the solar activity*", Journal of Geophysical Research, doi:10.1029/2007JE003046.

53. Banerjee, D., Mahalingam, V., and Panda, D.K., 2007, *"TL sensitivity of single chondrules from type 3 chondrites: Thermal metamorphism of chondrules in a nebular environment?"* Radiation Measurements, doi 10.1016/j.radmeas.2007.11.021.

54. Dhingra, D., 2007, "*Lunar and Planetary Science, Meeting Report"*, Current Science, v. 93, no.3, p. 283-285.

55. Dhingra, D., 2008, *"Exploring links between crater floor mineralogy and layered lunar rust",* Advances in Space Research, v. 42/2, p. 275-280.

56. Parthasarathy, G., Bhandari, N., Vairamani, M., and Kunwar, A.C., 2008 *"High-pressure phase of natural*

fullerene C60 in Iridium-rich Cretaceous-Tertiary boundary layers of Deccan Inter-trappean deposits, Anjar, Kutch, India", Geochim. Cosmochim. Acta, v. 72, No. 3, p. 978-987.

57. Srivastava, N., 2008, "*Titanium Estimates of the Central Peaks of Lunar Craters: Implications for Sub-surface Lithology of Moon"*, Advances in Space Research, v. 42/2, p. 281-284.

58. Taricco, Bhandari, N., Colombetti, P., and Verma, N., 2008. "*Mid 19th Century minimum of galactic cosmic ray flux inferred from ^{44}Ti in Allegan meteorite"*, Advances in Space Research, v. 41, p. 275-279.

Solar Physics

59. Ambastha, A., 2007, "*Signatures of Large Flares on Photospheric magnetic and Velocity Fields*", Bulletin of Astronomical Soceity of India, v. 35, p. 419-426.

60. Joshi, V. and Srivastava, N., 2007, "*On the study of kinematics of eruptive quiescent prominences observed in He 304 Å*", Bulletin of Astronomical Soceity of India, v. 35, p. 447-455.

61. Venkatakrishnan, P., Kumar, B., and Uddin, W., 2008, "*Co-spatial evolution of photospheric Doppler enhancements and H-alpha flare ribbons observed during the solar flare of 2003 October 28"*, Monthly Notices of Royal Astronomical Society, v. 387, p. L69-L73.

Space and Atmospheric Sciences

62. Gupta, S., Lal, S., Venkataramani, S., Rajesh, T.A., and Acharya, Y.B., 2007, "*Variability in the vertical distribution of ozone over a subtropical site in India during a winter month"*, Journal of Atmospheric and Solar-Terrestrial Physics, v. 69, p. 1502-1512.

63. Haider, S.A., Singh, V., Choksi, V.R., Maguire, W.C., and Verigin, M.I., 2007, "*Calculated densities of $H_3O^+(H_2O)_n$, $NO_2^-(H_2O)_n$, $CO_3^-(H_2O)_n$ and electron in the nighttime ionosphere of Mars: Impact of solar wind electron and galactic cosmic rays"*, Journal of Geophysical Research, 112, A12309, doi:10.1029/2007JA012530.

64. James, M.E., Rastogi, R.G., and Chandra, H., 2008, "*Day-to-day variation of geomagnetic H field and equatorial ring current"*, Journal of Indian Geophysical Union, v. 12, p. 63-71.

65. Kelley, M.C., Nicolls, M.J., Anderson, D., Anghel, A., Chau, J.L., Sekar, R., Subbarao, K.S.V., Bhattacharyya, A., 2007, "*Multi-longitude case studies comparing the interplanetary and equatorial ionospheric electric fields using an empirical model"*, Journal of Atmospheric Solar-Terrestrial Physics, v. 69, p. 1174-1181.

66. Lal, S., 2007, "*Trace gases over the Indian region"*, Indian Journal of Radio & Space Physics, v. 36, p. 556-570.

67. Mahajan, K.K., Singh, S., Kumar, A., Raghuvanshi, S., and Haider, S.A., 2007, "*Mars Global Surveyor radio science electron density profiles: Some anomalous features in the Martian ionosphere"*, Journal of Geophysical Research, v. 112 E10006, doi 10.1029/2006 JE002876.

68. Misra, A., Jayaraman, A., and Ganguly, D., 2008, "*Validation of MODIS derived aerosol optical depth over western India"*, Journal of Geophysical Research,v. 113, D04203, doi:10.1029/2007JD009075.

69. Pant, T.K., Tiwari, D., Vineeth, C., Thampi, S.V., Sridharan, S., Devasia, C.V., Sridharan, R., Gurubaran, S., and Sekar, S., 2007, "*Investigation on the mesopause energetics and its possible implications on the equatorial MLTI processes through coordinated daytime airglow and radar measurements"*, Geophysical Research Letters, v. 34, L15102, doi:10.1029/ 2007GL030193.

70. Rajesh, P. K., Liu, J., Sinha, H.S.S., Banerjee, S., Misra, R., Dutt, N., and Dadhania, M.B., 2007, "*Observations of plasma depletions in 557.7 nm images over Kavalur"*, Journal of Geophysical Research, doi:10.1029/2006JA012055.

71. Ramachandran, S., 2007, "*Aerosol optical depth and fine mode fraction variations deduced from Moderate Resolution Imaging Spectroradiometer (MODIS) over four urban areas in India"*, Journal of Geophysical Research, 112, D12607, doi:10.1029/2007JD008500.

72. Ramachandran, S., 2007, "*New Directions: Correspondence on How representative are aerosol radiative impact assessments?"*, Atmospheric Environment, v. 41, p. 5536-5540.

73. Ramachandran, S., 2008 "*Comment on Surface changes in solar irradiance due to aerosols over central Himalayas"*, Geophysical Research Letters, v. 35, L04814, doi:10.1029/2007GL030060.

74. Ramachandran, S., 2008, "*Comments on A method to estimate aerosol radiative forcing from spectral optical depths"*, Journal of Atmospheric Sciences, v. 65, doi:10.1175/2007JAS2414.1, p. 1099-1102.

75. Sekar, R., and Chakrabarty, D., 2007, "*Impact of space weather events on the coupling of ionosphere and thermosphere over low latitudes*", Asian Journal of Physics, v. 16, p. 247-272.

76. Sekar, R., Chakrabarty, D., Sarkhel, S., Patra, A.K., Devasia, C.V., and Kelley, M.C., 2007, "*Identification of active fossil bubbles based on coordinated VHF radar and airglow measurements"*, Annales Geophysicae, v. 25, p. 2099-2102.

77. Sharma, V., Bapat, B., Mondal, J., Hochlaf, M., Giri, K., and Sathyamurthy, N., 2007, "*Dissociative Double Ionization of CO_2: Dynamics, Energy Levels and Lifetime*", Journal of Physical Chemistry, A 111, i41, p. 10205-10211.

78. Sunil, S., Kumar, A., Singh, R. K., and Subramanian, K.P., 2008, "*Measurements of electron temperature and density of multi-component plasma plume formed by laser-blow-off of LiF-C film*" Journal of Physics D: Applied Physics , v. 41, 085211.

79. Verma, S., Venkataraman, C., Boucher, O., and Ramachandran, S., 2007, "*Source evaluation of aerosols measured during the Indian Ocean Experiment using combined chemical transport and back trajectory modeling*", Journal of Geophysical Research, v. 112, D11210, doi:10.1029/2006JD007698.

Theoretical Physics

80. Atre, R., Panigrahi, P.K., 2007, "*Controlling pulse propagation in optical fibers through nonlinearity and dispersion management*", Physical Review A, v. 76, p. 043838 (1-5).

81. Banerji, J., 2007, "*Exploring fractional revivals and sub-Planck structures: a walk in phase space with Wigner and Kirkwood*", Contemporary Physics, v. 48, p. 157–171.

82. Bhatt, J., Rangarajan, R., 2007, "*Thermalisation in thick wall electroweak baryogenesis*", Physical Review D, v. 75, p. 087305 (1-4).

83. Bhupal Dev, P.S., Djouadi, A., Godbole, R.M., Mühlleitner, M.M., Rindani, S.D., 2008, "*Determining the CP properties of the Higgs boson*", Physical Review Letter, v. 100, p. 051801 (1-4).

84. Das, S., Mohanty, S., Rao, K., 2008, "*Test of unparticle long range forces from perihelion precession of Mercury*", Physical Review D, v. 77, p. 076001 (1- 5).

85. Deb, S., Gupta, S.D., Banerji, J., and Gupta, S.D., 2007, "*Critical coupling at oblique incidence'*", Journal of Optics A: Pure and Applied Optics, v. 9, p. 555-559.

86. Fritzsche, S., Mani, B.K., and Angom, D., 2008, "*A Computer-Algebraic Approach to the Derivation of Feynman–Goldstone Perturbation Expansions for Open-Shell Atoms and Molecules*", Advances in Quantum Chemistry, v. 53, p. 177-215.

87. Gautam, S., and Angom, D., 2008, "*Critical temperature for Bose-Einstein condensation in quartic potentials*", European Physical Journal D, v. 46, p. 1436-1440.

88. Ghosh, S., and Banerji, J., 2007, "*A time–frequency analysis of wave packet fractional revivals*", Journal of Physic B: Atomic Molecular and Optical Physics, v. 40, p. 3545-3553.

89. Gu, P., and Sarkar, U., 2008, "*Leptogenesis, dark matter and Higgs phenomenology at TeV*", Nuclear Physics B, v. 789, p. 245-257.

90. Gu, P., He, H.-J.,.and Sarkar, U., 2008, "*Realistic neutrinogenesis with radiative vertex correction*", Physics Letters B, v. 659, p. 634-639.

91. Gu, P., He, H.-J., and Sarkar, U., 2007, "*Dirac Neutrinos, Dark Energy and Baryon Asymmetry*", Journal of Cosmology and Astroparticle Physics 0711, 016, p. 10.

92. Gu, P., He, H.-J., and Sarkar, U., 2007, "*Neutrino dark energy and baryon asymmetry from Higgs sector*", Physics Letter B, v. 653, p. 419-423.

93. Gupta, M., Pathak, A., Srikanth, R., and Panigrahi, P.K., 2007, "*General Circuits for Indirecting and Distribution Mesurement in Quantum Computation*", International Journal of Quantum Information, v. 5, p. 627.

94. Gurappa, N., Jha, P.K., and Panigrahi, P.K., 2007, "*On the Applications of a New Technique to Solve Linear Differential Equations, with and without Source*", SIGMA v. 3, p. 057.

95. Hemachander, S., Verma, A., Arora, S., and Panigrahi, P.K., 2007, "*Locally adaptive block thresholding method with continuity constraint*", Pattern Recognition Letters, v. 28, p. 119-124.

96. Hill, C.T., Mocioiu, I., Paschos, E.A., and Sarkar, U., "*Neutrino Phenomenology, Dark Energy and Leptogenesis from pseudo-Nambu-Goldstone Bosons*", Physics Letter B, v. 651, p.188-194.

97. Hirsch, M., Joshipura, A.S., Kaneko, S., and Valle, J.W.F., 2007, "*Predictive flavour symmetries of the neutrino mass matrix*", Physical Review Letters, v. 99, p. 151802 (1-4).

98. Jha, T., Mishra, H., and Sreekanth, V., 2008, "*On attributes of a rotating neu tron star with a hyperon core*", Physical Review C, v. 77, p. 045801 (1-11).

99. Joshipura A. S., 2008, "*Universal 2-3 symmetry*", European Physical Journal C, v. 53, p. 77-85.

100. Joshipura A. S., and Kodrani, B.P., 2008, "*Minimal flavor violations and tree level flavor changing neutral currents*", Physical Review D, v. 77, p. 096003 (1-9).

101. Kota, V.K.B., 2007, "*Deuteron Transfer in N=Z Nuclei in the* $SO_{sd}(36) \supset SO_s(6) \oplus SO_d(30)$ *Limit of Spin-Isospin Invariant Interacting Boson Model*", Progress in Theoretical Physics, v. 118, p. 893-901.

102. Kota, V.K.B., 2007, "$U(2\Omega) \supset (2\Omega) \otimes SU(2)$ *Wigner-Racah algebra for embedded Gaussian unitary ensemble of random matrices with spin*", Journal of Mathematical Physics, v. 48, p. 053304 (1-9).

103. Lambiase, G., Mohanty, S., 2007, "*Gravitational Leptogenesis*", Journal of Cosmology and Astroparticle Physics, v. 12, 008.

104. Latha, K.V., Angom, D., Das, B.P., Chaudhuri, R.K., and Das, B.P., 2008, "*Core polarization in coupled-cluster theory induced by a parity and time-reversal violating*

interaction", Journal of Physics B, v. 41, p. 035005 (1-6).

105. Ma, E., and Sarkar, U., 2007, "*Revelations of the E (6)/U (1)(N) Model: Two-Loop Neutrino Mass and Dark Matter*", Physics Letter B, v. 653, p. 288-291.

106. Majee, S., Parida, M.K., Raychaudhuri, A., and Sarkar, U., 2007, "*Low intermediate scales for leptogenesis in SUSY SO (10) GUTs*", Physical Review D, v. 75, p. 075003 (1-14).

107. Mani, Rao, C.R., Lakshmi, P.A., Pradhan, A., and Panigrahi, P.K., 2007, "*Wavelet Based Classification for Cancer Diagnosis*", Engineering Letters, v. 14 (2), p. 4.

108. Mishra, S., Sahu, R., and Kota, V.K.B., 2007, "*Deformed shell model for T=1/2 bands in ^{51}Mn*", Progress in Theoretical Physics, v. 118, p. 59-66.

109. Panda, S., Mohanty, S., Janardhan, P., Stal, O., 2007, "*Prospects for GMRT to Observe Radio Waves from UHE particles Interacting with the Moon*", Journal of Cosmology and Astroparticle Physics, 11, 022.

110. Rangarajan, R., Sahu, N., 2008, "Gravitino production in an inflationary universe and implications for leptogenesis", Modern Physics Letter A, v. 23, p. 427-436.

111. Rao, K., Rindani, S.D., 2008, "*Charged lepton distributions as a probe of contact interactions at a linear collider with polarized beams*", 2008, Physical Review D, v. 77, p. 015009, (1-29).

112. Sahu, N., and Sarkar, U., 2007, "*Explaining dark matter, dark energy, neutrino masses and leptogenesis at the TeV scale*", Physical Review D, v. 76, p. 045014, (1-5).

113. Shafieloo, A., Souradeep, T., Manimaran, P., Panigrahi, P. K., Rangarajan, R., 2007, "*Features in the Primordial Spectrum from WMAP: A Wavelet Analysis*", Physical Review D, v. 75, p. 123502 (1-7).

114. Singh, R.P., Roychowdhury, S., Jaiswal, V.K., 2007, "*Non-axial nature of an optical vortex and Wigner function*", Optics Communication, v. 274, p. 281-285.

115. Singh, S., and Sarkar, U., 2007, "*CP violation in neutrino mass matrix*", Nuclear Physics B, v. 771, p. 28-39.

Publications in Proceedings of Symposia

Astronomy and Astrophysics

1. Dewangan, L.K., Venkataraman, V., Purohit, R., Jain, J., Vadawale, S., and Anandarao, B.G., 2008, "*Transient XRF080109/SN2008D: Mt. Abu NIR Observations*", Published by GRB observation GCN, 7191.
2. Dewangan, L.K., Venkataraman, V., Purohit, R., Jain, J., Vadawale, S., and Anandarao, B.G., 2008, "*GRB 080212: Mt. Abu NIR Observations*", Published by GRB observation GCN, 7321.
3. Joshi, U.C., Ganesh, S., Baliyan, K.S., Glass, I.S., Nagata, T., 2006, "*Near infrared survey of the nuclear regions of the Milky Way*", in Proceedings IAU Symposium 235, Eds F Combes & J. Palous, Published by Cambridge University Press p. 119-122.
4. Terada, Y., Hayashi, T., Ishida, M., Makishima, K., Mukai, K., Dotani, T., Okada, S., Nakamura, R., Naik, S., Bamba, A., Morigami Suzaku K., 2008, "*Discovery of Hard X-ray Pulsations from the Rotating Magnetized White Dwarf, AE Aquarii*", Published by American Astronomical Society, HEAD meeting-10, 1003.
5. Williams, P.M., Varricatt, W.P., Marston, A.P., and Ashok, M.M., 2007, "*Mapping WR140 from Infrared Spectroscopy and Imaging*", Massive Stars in Interactive Binaries, Published by Astonomical Society of Pacific Conference Series 367, p. 285.

Planetary & Geosciences Division

6. Das, J.P., and Murty, S.V.S., 2007, "*Search for pre-compaction irradiation records in chondrules",* Antarctic Meteorites XXXI, 11-12.
7. Das, J.P., and Murty, S.V.S., 2007, "*Presence of insoluble organic matter in chondrule precursors*", Proceedings of the 9th International Conference on Gas Geochemistry, Taipei, Taiwan, 1-8, Oct. 2007, 161-165.
8. Ram. K., and Sarin, M.M., 2007, "*Atmospheric carbonaceous species (EC, OC): Temporal variability over a high altitude site in semi- arid region of western India",* Proceedings of the Conference on "Emerging Trends in Aerosols: Technology & Applications", National Physical Laboratory, New Delhi, IASTA Bulletin 2007, 173-175.
9. Ramesh, R., and Padia, J.T., 2007, "*Stable isotope systematics and their applications in Paleoclimate and paleoceanography, I. Stable isotope Systematics and experimental methods",* Refresher course on marine geology and geophysics (22nd October to 02nd November 2007) - Lecture notes, (Eds. Kessarkar, P.M., Mergulhao, L.P.), National Institute of Oceanography, Goa, India 240 pp., 22nd Oct- 2nd Nov 2007, 105-111.
10. Ramesh, R., and Padia, J.T., 2007, "*Stable isotope systematics and their applications in Paleoclimate and*

paleoceanography, II. Land based applications", Refresher course on marine geology and geophysics (22nd October to 02nd November 2007) - Lecture notes, (Eds. Kessarkar, P.M., Mergulhao, L.P.), National Institute of Oceanography, Goa, India 240 pp., 22nd Oct- 2nd Nov 2007, 105-111.

11. Ramesh, R., and Padia, J.T., 2007, "*Stable isotope systematics and their applications in Paleoclimate and paleoceanography, III. Application to Oceanography",* Refresher course on marine geology and geophysics (22nd October to 02nd November 2007) - Lecture notes, (Eds. Kessarkar, P.M., Mergulhao, L.P.), National Institute of Oceanography, Goa, India 240 pp., 22nd Oct- 2nd Nov 2007, 105-111.

12. Rengarajan, R., Sudheer, A.K., and Sarin, M.M., 2007, "*Characteristics of PM2.5 and PM10 aerosols at an Urban site during wintertime*". Proceedings of the Conference on "Emerging Trends in Aerosols: Technology & Applications", National Physical Laboratory, New Delhi, IASTA Bulletin 2007, 55-57.

13. Sarin, M.M., 2007, *"Dating of rocks & sediments by radioactive Methods"*. Lecture notes of Refresher Course on Marine Geology & Geophysics, Refresher course on marine geology and geophysics (22nd October to 02nd November 2007) - Lecture notes, (Eds. Kessarkar, P.M., Mergulhao, L.P.), National Institute of Oceanography, Goa, India 240 pp., 22nd Oct- 2nd Nov 2007.

14. Singh, A., Prakash, S., Ramesh, R., and Sudhakar, M., 2007, "*Ocean fertilization: recent results from the southern Ocean"*, Proceedings of National Conference on "Global Temperature Rise: An Indian Effort Towards Mitigation of Carbon di-oxide emissions: A Brain Storming Session", Andhra University, Visakhapatnam, Sep. 21-22, pp. 155-162.

Planetary Sciences and Exploration Programme

15. Srivastava, N., 2008, "*Hyperspectral Remote Sensing in Planetary Exploration*", Proc. National Seminar on Hyperspectral Remote Sensing and Spectral Signature database Management System- HYPERSPEC:, 39 - 45, Annamalai University, Chidambram, India.

16. Srivastava, N., 2008, *Pluto: No longer a Planet* for the CSSTEAP (Centre for Space Science and Technology Education in Asia and Pacific) News Letter, vol. 11, issue 1.

Solar Physics

17. Bayanna, R., Louis, R.E., Kumar, B., Mathew, S.K., and Venkatakrishnan, P., 2007, "*Development of a hybrid imaging system for Udaipur Solar Observatory*", Proc. of Society of Photo-Optical Instrumentation Engineers (SPIE), Published by 6689, 66890W.

18. Gosain, S., Venkatakrishnan, P., and Venugopalan, K., 2006, "*Acoustic power and magnetic field orientation in a large sunspot, in the Proceedings of SOHO 18/GONG 2006/HELAS I", Beyond the spherical Sun,* Eds. Michael Thompson and Karen Fletcher, Vol. ESA SP-624, 59-62.

19. Kumar, B., Venkatakrishnan, P., and Venugopalan, K., 2006, "*On the enhanced velocity oscillations observed during solar flares in the Proceedings of SOHO 18/GONG 2006/HELAS I", Beyond the spherical Sun,* Eds. Michael Thompson & Karen Fletcher, Vol. ESA SP-624, 65-69.

20. Sridharan, R., Bayanna, Louis, A.R., Kumar, B., Mathew, S.K., and Venkatakrishnan, P., 2007, "*An Image Stabilization System for solar observation*", Proc. of Society of Photo-Optical Instrumentation Engineers (SPIE), 6689, 66890Z.

21. Srivastava, N., 2006," *How good is the prediction of space weather based on solar and interplanetary properties? Proc of International Living With a Star (ILWS), (Goa) workshop",* Editors: N. Gopalswamy and A. Bhattacharyya., 102-106.

Space and Atmospheric Sciences

22. Chandra H., P.V.S. Ramarao, P.N. Vijay Kumar, B.M. Pathan, K.N. Iyer, A.K. Gwal, R.P. Singh, Birbal Singh and A. Dasgupta, "*VHF scintillations at low latitudes in the Indian region"*, Proc. International Radio Beacon Symposium, Boston College, Editor Patricia Doherty Boston College, Boston USA, 15-19 June (2007).

23. Chandra H., H.S.S. Sinha, R.N. Misra, S.R. Das , Uma Kota, D. Narayana Rao, A.K. Patra , S., C. Chakravarty and J. Datta, "*Mesospheric turbulence studies using rocket and Indian MST radar",* Proc. of the 11th International workshop on technical and scientific aspects of MST radar, Gadanki, India 11-15 December 2006; Ed. V. K. Anandan, Macmillan India Ltd., p.131-135 (2007).

24. Chandra H., Som Sharma and Soe Win Aung, "*Day to day variability in f_oF_2 over Ahmedabad"*, Proc. Indian CAWSES workshop, NARL, Gadanki, May 2007, ISRO HQ, Bangalore, p. 207-210 (2007).

25. Sharma S, Lal S, Jayaraman A, Acharya Y. B. and H. Chandra, "*Rayleigh lidar studies of middle atmospheric thermal structure over a high altitude sub-tropical station (Mt. Abu, 24.5^o N, 72.7^o E)"*, Proc. RIIS –2007, Reunion Island Int. Symp., Reunion Island, November (2007).

26. Thampi S. V., T.K. Pant, G. Manju, S. Banola, D. Tiwari, Sudha Ravindran, C.V. Devasia, H. Chandra and R. Sridharan, *"Investigation of day and night time scintillations over the low and equatorial latitudes in Indian region"*, Proc. Of the 11th International workshop on technical and scientific aspects of MST radar, Gadanki,

India 11-15 December 2006; Ed. V. K. Anandan, Macmillan India Ltd., p. 207-210 (2007).

27. Denman, K.L., Brassuer, G., Chidthaisong, A., Ciais, P., Cox, P., Dickinson, R.E., Hauglastaine, D., Heinze, C., Holland, E., Jacob, D., Lohmann, U., Ramachandran, S., Silva Dias, P.L. de., Wofsy, S.C., and Zhang, X., 2007, "*Couplings between changes in the climate system and biogeochemistry*", In : Climate Change 2007: The Physical Science Basis, Contribution of WGI to the Fourth Assessment Report of the IPCC S. Solomon, D. Qin, M. Manning, Z. Xhen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller Eds., Cambridge University Press, Cambridge, UK and New York, NY, USA, p.499-588.

Theoretical Physics

28. Kota, V.K.B., 2008, "*Nuclear Models and Statistical Spectroscopy for Double Beta Decay*", in 'Neutrinoless Double Beta Decay', edited by V.K.B. Kota and Utpal Sarkar (Narosa, New Delhi, India), p. 63-76.

29. Latha, K.V.P., Angom, D., Chaudhuri, R.K., Das, B.P., and Mukherjee, D., 2007, "*A new formulation of the relativistic many-body theory of electric dipole moments of closed shell atoms*", J. Phys.: published by Institute of Physics, UK, Conf. Ser. 80, 012049.

30. Mohanta, D., and Singh, R.P., 2007, "*Optical vortex generation and propagation through nonlinear (^{87}Rb) media*", Technical Digest, XXXIII Optical Society of India Symposium 2007 On Optics and Optoelectronics, 18-20 December, 2007, Tezpur University, Published by Optical Society of India, p.p.46-49.

31. Mohanty, S., 2007, "*Thermal effects in inflation power spectra*", 2nd International Conference on Quantum Theories and Renormalization Group in Gravity and Cosmology (IRGAC 2006), Barcelona, Spain, 11-15 Jul 2006, J.Phys. , published by Institute of Physics, UK A40: 7113-7119.

32. Rangarajan, R., *WMAPping the inflationary universe*, in Proceedings of the 17th DAE-BRNS High + Energy Physics Symposium (HEP06), IIT Kharagpur., Cygnus, Kolkata, India.

33. Rindani, S.D., 2007, *Transverse polarization in γ Z, HZ production*, Proc. of the International Linear Collider Workshop (LCWS06), Bangalore, India, 9-13 Mar. 2006, Pramana 69, Indian Academy of Science, Bangalore, p. 883-887.

34. Singh, R.P., and Jaiswal, V.K., 2007, *Polychromatic Vortex: An Interferometric Investigation*, Frontiers in Optics 2007/ Laser Science XXIII (91st OSA Annual meeting), San Jose, California, Optical Society of India, September p.16-20.

Books/Monographs/Review Articles

1. Achyuthan, H., and Ramesh, R., 2007, "*Quaternary paleoclimatic inferences based on stable isotope studies* of *calcretes*" Indian Journal of Geochemistry, 22(1), p. 105-124.
2. Ambastha, A., 2007, *Solar Activity*, in Kodai School on Solar Physics, Eds. Hasan, S., and Banerjee, D., American Inst. Physics Conf. Proc., v. 919, p. 173-213.
3. Anandarao, B.G., 2008, "*Stargazers have an eventful decade*": in Innovative India Rises, Ed. L.K. Sharma, Medialand, London, p. 139-142.
4. Banerji, J., Panigrahi, P.K., and Singh, R.P., (Eds.), 2007, "Quantum Optics: Coherence, Entanglement and Nonlinear Dynamics", Macmillan India Ltd., Delhi.
5. Buesseler, K. O., Antia, A. N., Chen, M., Fowler, S. W., Gardner, W. D., Gustafsson, O., Harada, K., Michaels, A. F., Rutgers., Sarin, M. M., Steinberg, D. K., Trull, T., 2007, "*An assessment of the use of sediment traps for estimating upper ocean particle fluxes*": Journal of Marine Research, v. 65, No. 3., p. 345-416.
6. Church, T., and Sarin, M. M., 2008, "*U and Th Series Nuclides in the Atmosphere: Supply, change, Scavenging and Applications to Aquatic Processes*". In: U and Th Series Radionuclides in Aquatic Systems (Publisher: Elsevier, Oxford UK, Eds: S. Krishnaswami and J.K. Cochran**)** Chapter 2**,** p. 11-47.
7. Desai, J. N., Ashok, N.M., and Shah, H.S., 2007, *The Sun*: Vigyan Prasar, Department of Science and Technology, Government of India.
8. Gandhi, A.J., Ramachandran, S., and Anilkumar, N., 2008, RFID Technology for Libraries: A case study of its implementation at PRL, Ahmedabad in "*Radio Frequency Identification in Libraries : Concepts and Cases*", edited by Smitha Ramachandran, ICFAI University Press, Hyderabad, p102-110.
9. Jayaraman, A., Joshi, P. C., and Ramesh, R., 2007, "*Developments and achievements in atmospheric sciences and space meteorology*": Current Sciences, v. 93, 12, p. 1779-1790.
10. Kota, V. K. B., and Sarkar, U., 2007, "*Neutrinoless Double Beta Decay*": eds. Kota, V. K. B., and Sarkar, U., eds. Narosa, New Delhi, India, 2007, p. 1-160.
11. Moortgat-Pick, G., Rindani, S. D, et al., 2008, "The Role of polarized positrons and electrons in revealing fundamental interactions at the linear collider", Phys. Rept., v. 460, p. 131-243.
12. Padia, J. T., Yadava, M. G., and Ramesh, R., 2007,

"*Stable isotopes and radiocarbon dating and their application to soil studies"*: Indian Journal of Geochemistry, v. 22(1), p. 3-32.

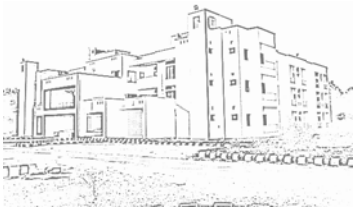
13. Raina, P. K., Rath, P. K., Pillay, R. G., Nanal, V., Datar, V. M., Srivastava, A., Kota, V. K. B., and Sarkar, U., 2007, *Introduction*, in Neutrinoless Double Beta Decay: eds Kota, V. K. B., and Sarkar, U., Narosa, New Delhi, India, p. 1-10.
14. Sarkar, U., 2007, "*Importance of neutrinoless double beta decay"*: in Neutrinoless Double Beta Decay, eds V.K.B. Kota and U. Sarkar., Narosa, New Delhi, India, p. 11-20.
15. Sarkar, U., 2007, *Leptogenesis,* "*Dark Energy, Dark Matter and the neutrinos"*: in International Workshop on Theoretical High Energy Physics (IWTHEP 2007), Roorkee, UA, India, AIP Conf. Proc. 939 (2007) p. 124-133.
16. Sarkar, U., 2007, "*Particle and Astroparticle Physics":* Taylor and Francis, New York, USA, p. 1-544.
17. SCOR Working Group (S Krishnaswami is a member) "GEOTRACES – An international study of the global marine biogeochemical cycles of trace elements and their isotopes, Chemie der Erde 67, 2007, p. 85-131.
18. Sekar, R., and Chakrabarty, D., 2008, "*Equatorial Spread-F research in India: A brief review"*, Indian Journal of Radio & Space Physics, v. 37, p. 7-27.
19. Singh, A. K., Yadava, M. G., and Ramesh, R., 2007, "*High resolution monsoon records from land and the ocean":* what have we learnt during the last decade? Jal Vigyan Sameeksha (Hydrology Review), 22, 2007, p. 177-190.
20. Singh, S.K., 2007, "*Erosion and Weathering in the Brahmaputra River System, in Large Rivers: Geomorphology and management*" (Ed. Avijit Gupta), John Wiley & Sons, Ltd, UK , p. 373-393.
21. Tiwari, M., and Ramesh, R., 2007, **"***Solar variability in the past and paleoclimatic data pertaining to southwest monsoon –a review "*: Current Science, v. 93 (4), p. 477-487.

Technical Reports

1. Pabari, J., 2007, "*Submillimeter Schottky Mixer Optimisation and Biasing*", PRL-TN-2007-88, March.
2. Rajesh, T. A., 2007, "*Real time data acquisition in windows for 8 channel analog input module-ADAM4017+*", PRL-TN-2007-89, June.

Publications for Education

1. Baliyan, K.S., and Vats, H.O., 2008, "*Role of Physics in the interpretation of the Astrophysical Phenomena"*, Proceedings, National Conference on Convergence with Physics, Surabhi Printing House, Jamshedpur, p. 104-111.
2. Panigrahi, P.K., 2007, "*Harmonic Oscillator: A Different Perspective*", Physics Education, v. 23, p. 135-138.
3. Vats, H.O., 2008, "*Scientific excitements and opportunities in Physics"*, Malviya National Institute of Technology, Jaipur, 23 January.
4. Vats, H.O., Baliyan, K.S., 2008, "*Physics Education through models, simulation and experiment",* Proceedings, National Conference on Convergence with Physics, Surabhi Printing House, Jamshedpur, p. 245-256.
5. Vyas, M., and Panigrahi, P.K., 2007, "*Generic Solutions of Commonly Encountered Equations"*, Physics Education, v. 23, p. 299-302.



Facilities and Services

Facilities and Services

Administration

Activities on the Promotion of National Language

PRL strives to implement the use of use of Hindi through a variety of programmes and symposia. The activities during the past year included, 1) the Hindi Pakhwada during September 14 - 28, 2007 comprising word quiz, essay, elocution, Hamara Karya, self written poetry competitions; 2) a technical seminar in Hindi on Societal Importance of PRL's Research Activities on 13 March, 2008, (fourteen members presented their papers in this Seminar); 3) a day long workshop during June 2007 in Hindi and 4) a two day workshop during March 2008; 5) A symposium on Vishwa Manch Par Hindi.

Shri R.S. Gupta, Hindi Officer-II delivered lectures in Hindi workshops held by various Departments like Space Applications Centre, Airports Authority, Food Corporation of India, Income Tax, Doordarshan on different topics including applications of computers in Hindi.

Sports

PRL Staff Members participated in the DOS/ISRO Inter Centre sports Meet 2007 (Indoor) and secured the second place. PRL won, 1) the third rank in Chess Open Tournament (Mr. V.M.Shah); 2) the third rank in Team event (M/s. V.M. Shah, S.K.Shah, V. Ranganathan and P.G. Thomas; 3) Third rank in the progressive event in BRIDGE (M/s. Y.M. Trivedi, A.P. Gohil, P.K. Sivadasan, S.M. Yadav, J.A. Patel and Mr. P. G. Thomas).

Administration

A day long workshop on Pay Fixation and Pensioners Benefits was organized on 31 August 2007. Over forty staff members participated. Administrative staff of PRL attended the in-house training programme conducted by Various ISRO Centers during the year 2007-2008. Mr. N. R. Pillai and Ms. V. Leela Iyer attended a one day Seminar on Records Management at the National Institute of Design, Paldi, Ahmedabad. Mr. C.V.R.G. Deekshitulu and Mr. N.R. Pillai, attended a two day training Programme on Individual and Team Effectiveness for Better Performance, held at Ahmedabad Management Association, Ahmedabad during March, 2008.

Computer Centre

The Computer Centre is now equipped with, 1) IBM Power 5 Machine with 4 processors and 8GB RAM, 2) four HP

servers, each with Four AMD processors, 4 GB RAM, 1.5 TB disk space and 3) two Dual Processor Xeon based servers. These provide for high end computing and disk storage. These computing machines are accessible through a high-speed (100/1000 Mbps) local area network (LAN), to provide easy, fast and reliable access to more than 200 PC's and workstations distributed throughout all the campuses. This year, the connectivity between Udaipur Solar Observatory (USO) and PRL main campus was upgraded from 64 Kbps to 2 Mbps through a BSNL – MLLN (Managed Leased Line Network). The Thaltej campus is connected over a 40 Mbps 5.4 GHz Microwave Non Line of Sight Link that enables a clock connectivity to users at Thaltej, USO, and Abu. Further the main campus was connected to the Thaltej campus via BSNL's 2 Mbps MLLN for voice communication providing intercom telephone facility between the campuses. The Centre provides centralized virus free E-mails by automatically scanning all incoming E-mails. Anti-Spam filter has been centrally installed to eliminate the spam mails. The center provides web enabled email service. Internet authorizations, monitoring and reporting functions have been added to have optimal usage of Internet bandwidth.

PRL has assumed the role of a resource partner of C-DAC's Grid Garuda Project. The Grid Garuda network was integrated to PRL LAN providing seamless access of Garuda resources. The SPACENET connectivity for Data, Intranet, and video conferencing was established for interaction with ISRO centers. Mathematical, numerical and visualization application software like IMSL, IDL, Mathematica, Sigma Plot, MATLAB, Lahey FORTARN 95, and Data Explorer etc. have also been installed to cater the needs of the scientific community.

Library and Information Services

During the past year, the library implemented the radio frequency identification (RFID) Security System which provides for security and saves the time of the user at the circulation counter by way of issuing/ returning multiple items at a time. It would also help in stock verification of books.

The library continued to subscribe to full-text databases like Science Direct, GSA Archive, IOP Archive, PROLA, Scientific American Online Archive, Lecture Notes in Physics and provided document delivery service through inter library loans and through a commercial vendor – Scientific and Technical Network, Germany. The users were updated on the 'Recent Arrivals' through email and an e-mail could also be used for renewals. The library assisted the students and scientists in book procurements under book grants. An institutional repository using the open source software - Greenstone Digital Library Software (GSDL) was also created. This contains research articles by PRL authors (from 1995 onwards) and can be retrieved through year-wise data or by a search option comprising the author name, title, journal name, publisher or a combination of these.

During 2007-2008, 247 technical books, 163 Hindi books and 77 CDs/DVDs were added. This took the book count at PRL to 18424 books (Main and Thaltej libraries), 2069 books in USO library, 1861 Hindi books and 921 Audio-Visual materials. Of the 149 journal titles, currently subscribed, 140 are available online. Library supplements the available resources through active resource sharing with other local and national libraries. In 2007-2008, PRL library catered to 197 requests of other libraries and 162 requests, of PRL users were met through supplies from other institutions.

Workshop

PRL Workshop is a general-purpose mechanical workshop providing support to scientific programmes. The workshop has a wide range of machines such as metal cutting, welding and CNC Lathe Machines. The workshop helps in designing, developing and manufacturing precise mechanical components, instrument parts, vacuum chambers etc. for different experimental set up.

The workshop also carries out sheet and structural metal fabrication jobs. The high vacuum welding joints are also made using the TIG welding machine. The workshop is also equipped with one CNC lathe machine for precision turning jobs. Various lens adaptor, optical components and mounts were also fabricated at the workshop.

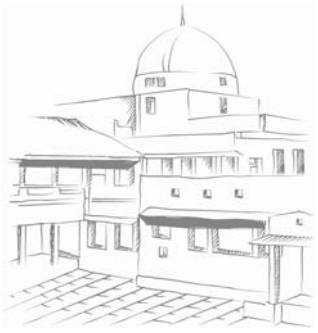
Some of the major works carried out during the year are listed below

1. Fabrication of *Low Resolution Spectrograph (LORES)*

Figure 34 : Fabtrication of Low Resolution Spectrograph in PRL workshop

(Figure 34) using Volume Phased Holographic (VPH) Grating was designed and fabricated in workshop. This was made-up of aluminum alloy material. This job involves high accuracy and alignment of 0.05 degree is aimed to observe faint, up to 15th magnitude stars. Efforts to improve its auto-guider are underway.

2. Fabrication of conical condensation device, comprising metallic stand with eight adjustable screws to hold the metallic cone for atmospheric moisture condensation studied. Ice placed in the cone, and covered with a lid causes the condensation of atmospheric moisture on the outer surface of the cone. The droplets flow along the inclined surface of the cone and eventually fall in the plastic bottle kept at the base. The cone can be positioned vertically with the help of 8 screws such that it is located just above the plastic bottle placed in the groove made in the base plate. The assembly consisted of a top Ring, a Base plate, a Cone, four Al. studs, several of M5 and winged nuts, nuts, PVC top cover with knobs and a wire mesh.
3. Fabrication of seventy rain water collection devices comprising a metallic M.S slotted angle pieces to secure a 20 liter carbuoy for collecting the rainwater sample. Extended legs on four sides ensure the strong wind or inadvertent movement. The metallic base plate provides a steady and flat base for the carbuoy. For the collection a funnel was used and a SS piece was connected at the base of the PVC tube to keep the tube vertically straight and permit unhindered flow of the water from funnel to flow into the carbouy. 1/8" SS tube is used for air outlet of the carbuoy. The air displaced by the water accumulating in the carbuoy, flows out through a 1/8" SS tube.
4. Fabrication of a die unit for sample preparation for X-ray fluorescence analysis. A die and punch was designed and machined using hardened steel to make aluminum cups of 0.3 mm thick sheet. Another die and punch was made for pressing the sample in to the cups to prepare pellets.
5. Fabrication of a centrifuge rotor head using aluminum alloy sheet. This involved, machining accuracy of 50 Microns and angular on the peri-pheral holes.
6. Fabrication of hex-payload prototype for the Chandrayan mission. This involved fabrication of seven different trays as per design with high accuracy milling work. Some other accessories and components made for testing purpose.
7. Fabrication of a guide tube assembly for the telescope at Udaipur. This implied precision fabrication of different parts like CCD coupler, lens holder, a tube with adjustable DD filter, etc.
8. Fabrication of precision work on CNC lathe machine including fabrication of flat aluminum discs, flanges, studs and dies for various experiments.



Honorary Fellows and Faculty

Honorary Fellows

Professor J.E. Blamont

Academician V.L. Ginzburg

Professor A.M.J. Tom Gehrels

Professor D. Lal, FRS

Professor M.G.K. Menon, FRS

Professor U. R. Rao

Professor P. Crutzen

Professor K. Kasturirangan

Professor A. Hewish

Academic Faculty

Name	Designation	Specialisation	Academic Qualification
Goswami J. N. FNA, FASc, FNASc, FTWAS	Director	Solar System Studies (Pre - Solar Processes)	Ph D, PRL, Gujarat Univ. (1978)
Ambastha A. K.	Professor	Solar Plasma Physics, Coronal Structure and Polarization	Ph D, PRL, Gujarat Univ. (1981)
Amritkar R. E. FASc	Professor	Nonlinear Dynamics & Chaos	Ph D, IISc, Bangalore (1978)
Ashok N. M.	Professor	Close Binary Stars, Novae IR spectroscopy	Ph D, PRL, Gujarat Univ. (1983)
Baliyan K. S.	Associate Professor	AGNs, Comets, Atomic Physics, Milky Way	Ph D, Roorkee Univ. (1986)
Banerjee D.	Reader	Thermoluminscence & Planetary Physics	Ph D, PRL Gujarat Univ. (1996)
Banerjee D. P. K.	Associate Professor	Novae, Be Stars, Planetary Nebulae, IR and Optical Studies	Ph D, PRL, Gujarat Univ. (1991)
Banerji J.	Professor	Laser Physics	Ph D, City Univ.(New York) (1982)
Bapat B.	Reader	Atomic Collisions	Ph D, TIFR, Mumbai Univ. (1997)

Bhatt J. R.	Reader	Astrophysics	Ph D, IPR, MS Univ. (1992)
Bhattacharya S. K. FASc, FNASc	Senior Professor	Isotope Geochemistry	Ph D, PRL, Gujarat Univ.(1980)
Chakraborty A.	Reader	Extra-solar planets, Star Formation & Instrumentation	Ph D, PRL, Gujarat Univ. (1999)
Chakraborty S.	Reader	Stable Isotope Mass-spectrometry	Ph D, PRL, Gujarat Univ.(2004)
Chandrasekhar T.	Professor	High Angular Resolution Studies, Late type stars Solar Coronal Studies Comets	Ph D, PRL, Gujarat Univ. (1982)
Deshpande R. D.	Scientist-SE	Application of Environmental Tracers in Hydrology	Ph D, M S Univ. (2007)
Ghosh D. K.	Reader	Particle Physics	Ph D, Bombay Univ. (2000)
Goswami S.*	Associate Professor	High Energy Physics	Ph D, Calcutta Univ. (1998)
Haider S. A.	Associate Professor	Planetary and Cometary Atmospheres	Ph D, Banaras Univ. (1984)
Jain R.	Associate Professor	Solar Physics	Ph D, PRL, Gujarat Univ. (1983)
Janardhan P.	Associate Professor	Solar Radio Astronomy & Space Weather	Ph D, PRL, Gujarat Univ. (1992)
Joshi B.*	Scientist-SD	Solar Physics, Astronomy	Ph D, ARIES, Kumaun Univ (2007)
Joshi U. C.	Professor	AGNs, Milky way, Star Formation and Comets	Ph D, Kumaun Univ. (1981)
Joshipura A. S. FNA, FASc, FNASc	Senior Professor	Particle Physics	Ph D, Bombay Univ. (1979)
Juyal N.	Scientist-SE	Quaternary Geology & Paleoclimate	Ph D, M.S.Univ. (2004)
Kota V. K. B.	Senior Professor	Nuclear Physics	Ph D, Andhra Univ. (1977)
Lal S. FNA, FASc, FNASc	Senior Professor	Atmospheric Chemistry of Trace Gases	Ph D, PRL, Gujarat Univ. (1982)
Mahajan N.	Reader	Particle Physics	Ph D, Delhi Univ. (2003)
Marhas K. K.	Reader	Solar System studies	Ph D, PRL, DAVV Indore (2001)
Mathew S. K.	Reader	Solar Magnetic & Velocity Fields	Ph D PRL, Gujarat Univ. (1999)
Mishra H.	Associate Professor	Strong Interaction Physics & Nuclear Astrophysics	Ph D, IOP, Utkal Univ. (1994)
Mohanty S.	Professor	Astroparticle Physics	Ph D, Wisconsin Univ. (1989)
Murty S. V. S. FASc	Professor	Isotope Cosmochemistry	Ph D, IIT, Kanpur (1981)
Naik S.	Scientist-SD	High Energy Astro- physics, X-ray Binaries	Ph D, TIFR, Mumbai Univ. (2003)

Pallam Raju D.*	Associate Professor	Space and Atmospheric Sciences	Ph D, PRL, DAVV Indore (1996)
Panigrahi P. K.	Associate Professor	Field Theory	Ph D, Rochester Univ. (1988)
Rai V.	Reader	Stable Isotope Cosmochemistry	Ph D, PRL, MS Univ. (2001)
Ramachandran S.	Associate Professor	Atmospheric Aerosols Radiative & Climate Impacts	Ph D, PRL, MS Univ. (1996)
Ramesh R. FNA, FASc, FNASc, FTWAS	Senior Professor	Paleoclimatology, Oceanography & Modelling	Ph D, PRL, Gujarat Univ. (1984)
Rangarajan R.	Associate Professor	Particle Physics & Cosmology	Ph D, Univ. of California, Santa Barbara (1994)
Rao B. G. A.	Senior Professor	Star formation, Planetary Nebulae, AGB Stars and Imaging Fabry Perot Spectroscopy	Ph D, PRL, Gujarat Univ. (1978)
Ray J. S.	Reader	Isotope Geochemistry	Ph D, PRL, MS Univ. (1997)
Rengarajan R.	Scientist-SE	Atmospheric aerosols & aqueous geochemistry	Ph D, PRL, MLS Univ. (2004)
Rindani S. D. FNA	Senior Professor	Particle Physics	Ph D, IIT, Bombay (1976)
Santhanam M. S.	Reader	Non-linear Dynamics & Time Series Analysis	Ph D, PRL, Gujarat Univ. (1999)
Sarin M. M. FASc, FNA	Senior Professor	Geochemistry and Oceanography	Ph D, PRL, Gujarat Univ. (1985)
Sarkar U. FNA, FASc	Senior Professor	Particle Physics	Ph D, Calcutta Univ. (1984)
Sekar R.	Associate Professor	Upper Atmospheric & Ionospheric Physics	Ph D, PRL, Gujarat Univ. (1991)
Sharma P.	Scientist-SF	Geophysics and Hydrology	Ph D, PRL,Gujarat Univ. (1977)
Sheel V.	Reader	Modelling of Lower Atmosphere	Ph D, PRL, Guj. Univ. (1996)
Singal A. K.	Reader	Radio Astronomy & Astrophysics	Ph D, TIFR, Bombay Univ. (1986)
Singh A. D.	Reader	Atomic Physics	Ph D, IIA, Bangalore Univ. (1998)
Singh R. P.	Scientist – SE	Laser Physics	Ph D, JNU, N. Delhi (1994)
Singh S. K.	Reader	Isotope Geochemistry	Ph D, PRL, MS Univ. (1999)
Singhvi A. K. FNA, FASc, FNASc, FTWAS	Senior Professor	Palaeoclimatology and Geochronology	Ph D, IIT, Kanpur (1975)
Srivastava N.	Reader	Solar Physics	Ph D, PRL, Ravi Shankar Shukla Univ. (1994)
Subramanian K. P.	Associate Professor	Experimental Atomic and Molecular Physics	Ph D, PRL, Gujarat Univ. (1987)
Trivedi J. R.	Scientist- SF	Isotope Geochemistry	Ph D, PRL, Gujarat Univ. (1991)

Vadawale S. V.	Reader	High Energy Astrophysics and X - ray Spectroscopy	Ph D, TIFR, Mumbai Univ. (2003)
Vats H. O.	Associate Professor	Space Weather & Radio Astronomy	Ph D, PRL, Gujarat Univ. (1979)
Venkatkrishnan P.	Senior Professor	Solar Physics	Ph D, Bangalore Univ. (1984)
Yadava M. G.	Scientist-SE	Palaeoclimate, Radiocarbon dating and Stable isotopes	Ph D, DAVV Indore (2003)

* *Joined in 2008*

Engineering and Technical Faculty

Name	Designation
Acharya Y. B.	Engineer-G
Bhushan R.	Scientist-SE
Dadhania M. B.	Engineer-SE
Dholakia G. G.	Scientist-SG
Dutt N.	Engineer-SE
Gohil A. P.	Engineer-SE
Jokhakar D. H.	Engineer-SE
Mishra R. N.	Engineer-G
Modh K. S.	Engineer-SE
Narayanan R.	Scientist-SE
Prajapati I. A.	Scientist-SE
Rao D. K.	Scientist-SE
Shah A. B.	Engineer-SE
Shah K. J.	Scientist-SE
Shah R.R.	Engineer-SE
Shah S.K.	Scientist-SE
Subhedar D. V.	Engineer-SG
Ubale G. P.	Engineer-SE
Vadher N. M.	Engineer-SE
Venkataramani S.	Scientist-SE








सत्यम्





















सुंदरम्







शिवम्


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

पीआरएल के
अनुसंधान क्षेत्र में
समविष्ट हैं
पृथ्वी एवं
सूर्य
जो निमीलित हैं
चुंबकीय क्षेत्र एवं विकिरण में
अनंत से अनंत तक
जिन्हे प्रकट कर सकती है
मानव की जिक्षासा एवं विचारशक्ति