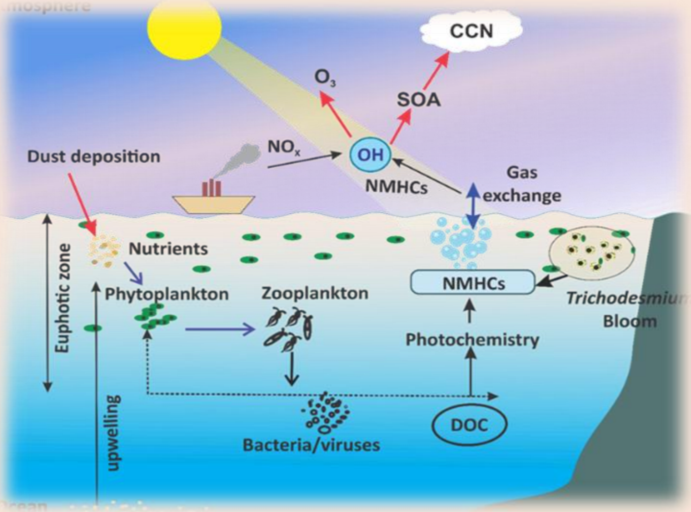
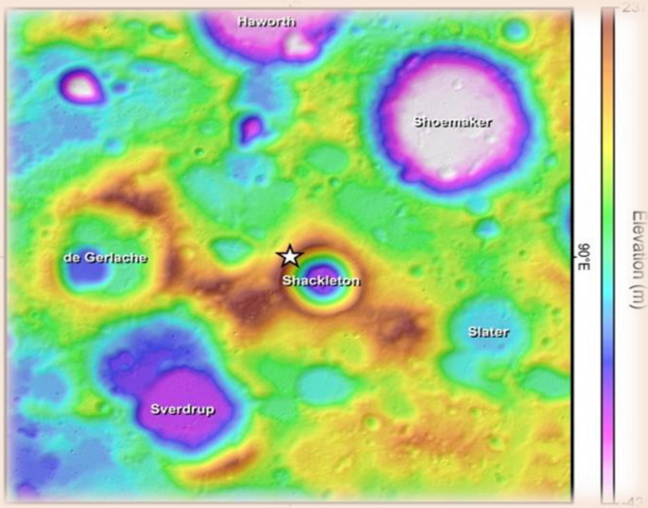
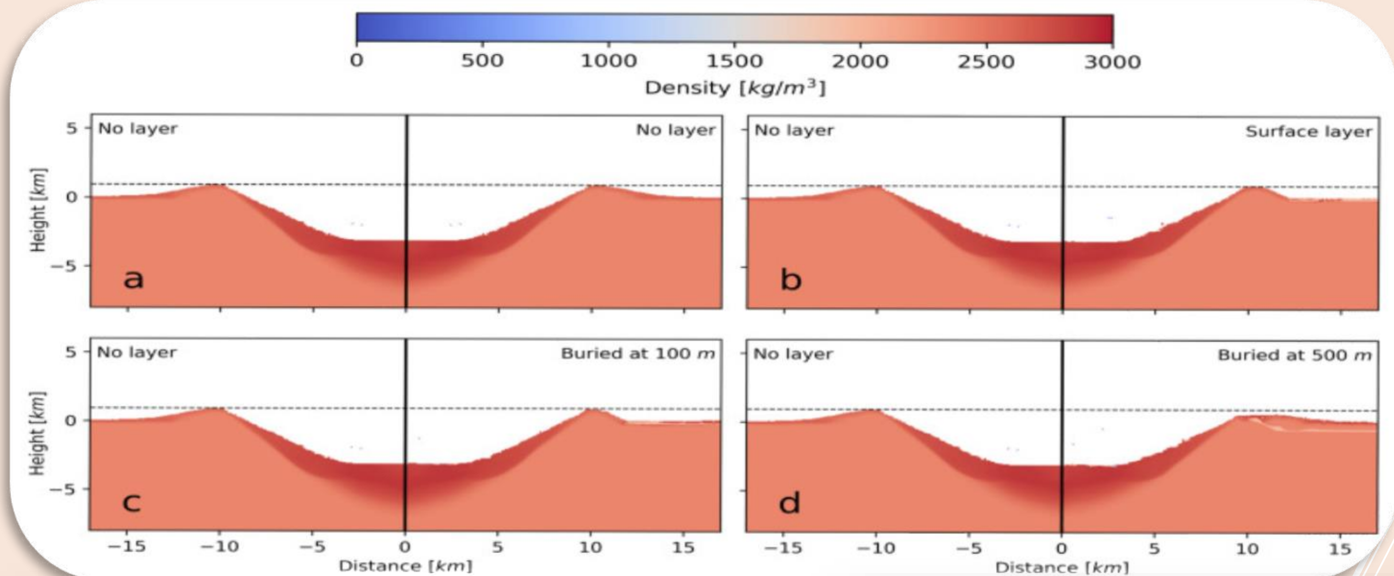
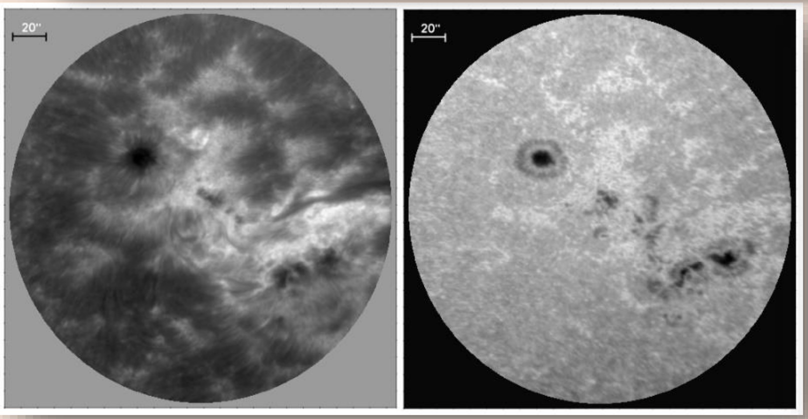
PRL NEWS – THE SPECTRUM

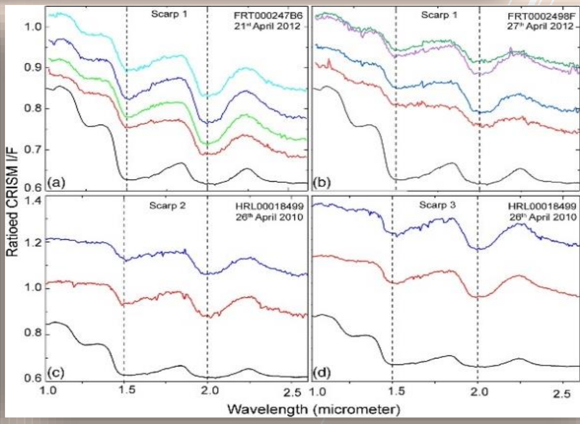
December 2020











Physical Research Laboratory
Ahmedabad - 380009
India

भौतिक अनुसंधान प्रयोगशाला
अहमदाबाद-380009
भारत

Website: https://www.prl.res.in/prleng/newsletter
Contact: newsletter@prl.res.in

Elevated levels of biogenic non-methane hydrocarbons in the marine boundary layer of the Arabian Sea during the inter-monsoon

Nidhi Tripathi, L. K. Sahu, Arvind Singh, Ravi Yadav, Anil Patel, Kashyap Patel, Meenu P.

Nidhi Tripathi

Ocean surface acts as a source or sink for several trace gases including N_2O, CH_4, CO, volatile organic compounds (VOCs). Among these gases, VOCs have profound effects in the marine atmosphere as their air sea exchange can influence the composition and chemistry of the marine atmosphere in different ways (Figure 1). The role of ocean in the global budget of VOCs is still unclear due to the paucity of measurements. The Arabian Sea is one of the most biologically productive ocean regimes and hence possesses a perennially intense oxygen minimum zone. High productive oceans can potentially modify the production and sea-to-air exchange of trace gases including VOCs. We measured non-methane hydrocarbons (NMHCs) in the marine air and characterized phytoplankton species in seawater of the Arabian Sea during the pre-monsoon season of the year 2017. The light alkenes namely ethene and propene were the dominant VOCs in the marine air with average mixing ratios of 8.92±3.50 and 3.38±1.30 ppbv, respectively (Figure 2). The high levels of alkenes were associated with the higher abundances of *Trichodesmium* and *Thalassiosira* species. We have calculated the estimated emission fluxes of ethene using "top-down" and "bottom up" approach and found the large discrepancies using these two methods. In the bottom-up approach, among the several sources of uncertainty, the major cause of lower fluxes (one order of magnitude) than those estimated using the top-down approach could be the emissions of alkenes from the sea surface microlayer. The estimated emission flux of ethene using "bottom-up" approach ($2.0\text{-}6.9\times10^9$ molecules cm^{-2} s^{-1}) was higher than those reported for several other oceanic regions. Such high emission rates of NMHCs in remote regions can significantly affect the regional tropospheric oxidation chemistry. Several studies reported that the emission of NOx from shipping over the northern Indian Ocean has increased significantly during last two decades. In the presence of NOx, VOCs act as an important source of atmospheric pollutant such as ozone, secondary organic aerosol and peroxy-acetyl nitrate. Our observations highlight the need to evaluate the biogeochemical processes controlling the oceanic emissions of NMHCs over the northern Indian Ocean.

Journal of Geophysical Research: Atmospheres
https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020JD032869

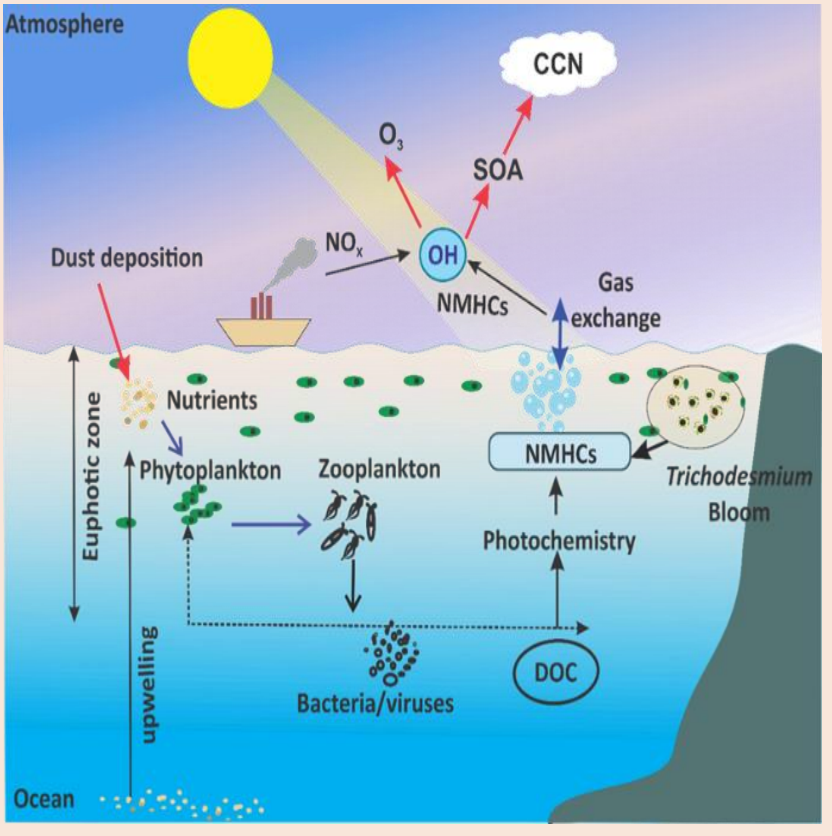


Figure 1. Emission from phytoplankton and dissolved organic carbon (DOC) present in seawater is an important natural source of many non-methane hydrocarbons (NMHCs) in the marine boundary layer (MBL).

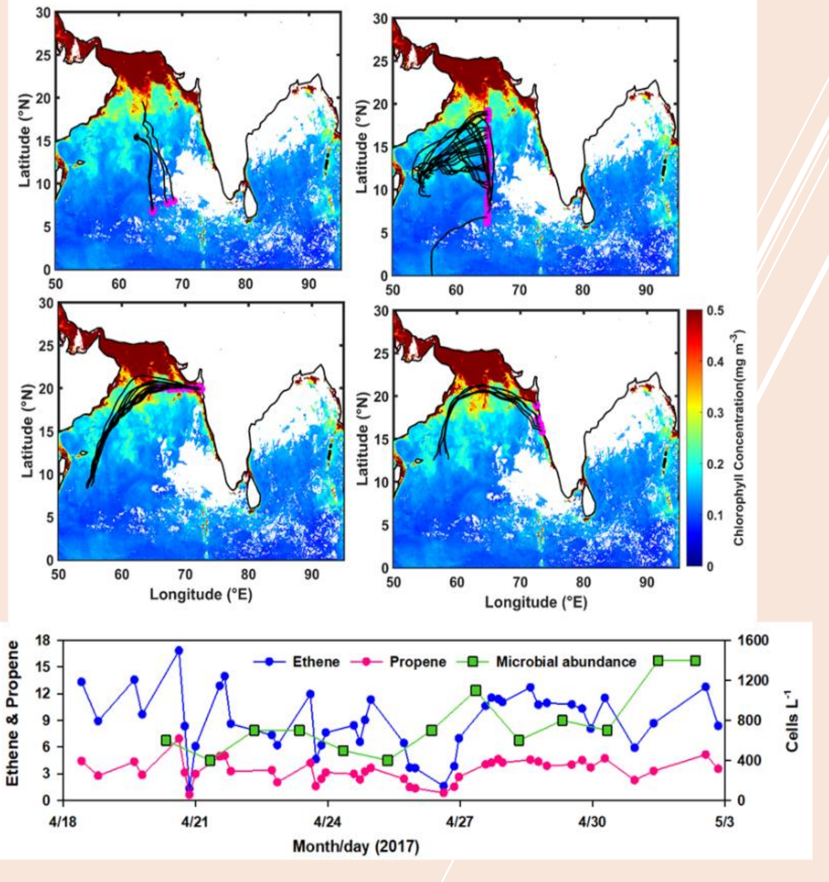


Figure 2. 5-day back trajectories at 100 m above mean sea level overlaid on surface Chl-*a* concentration at different air sampling locations (pink circle). Time series of the mixing ratios (ppbv) of ethene and propene in the marine air and total diatom species in seawater.

Harish

Water-Ice Exposing Scarps within the Northern Midlatitude Craters on Mars

(Harish, S. Vijayan, N. Mangold, and Anil Bhardwaj)

Mars is rich in water ice which is mostly preserved a few meters below the surface and suggested to covers nearly one-third of the planet. However, direct evidence of exposed water ice is limited to southern highlands of Mars and only one location is known in the northern lowlands of Mars. Identification of new water ice rich locations is indeed required to know the distribution of water ice on Mars. Additionally, discovery of new water ice rich locations will have a vital role in recognising future landing/robotic missions on Mars and even for the in situ resource utilization. Recent high-resolution visible images and infrared wavelength-dependent spectral signatures i.e. absorptions at 1.5 and 2.0 micrometres provide more diagnostic evidence for water ice. In this study, we have discovered water-ice exposures within two craters located in the northern hemisphere of Mars. We determined that these craters have formed ~25 and 95 million years ago, and water-ice deposited after the craters' formation and compacted within the craters over the time. We also determined the upper age of the exposures and suggested that the water-ice exposed within the last 1 million year. Ages determined in this study also suggest that snow/ice accumulation in the northern midlatitude of Mars potentially occurred with the last few million years. These exposures are found in the crater wall and on the crater floor. We found that the exposed ice is stable on one location after 1 week of interval using the spectral analysis that gives a direct evidence for the stable exposed water-ice. Thus, we concluded that water ice is widespread few meters below the surface of Mars.

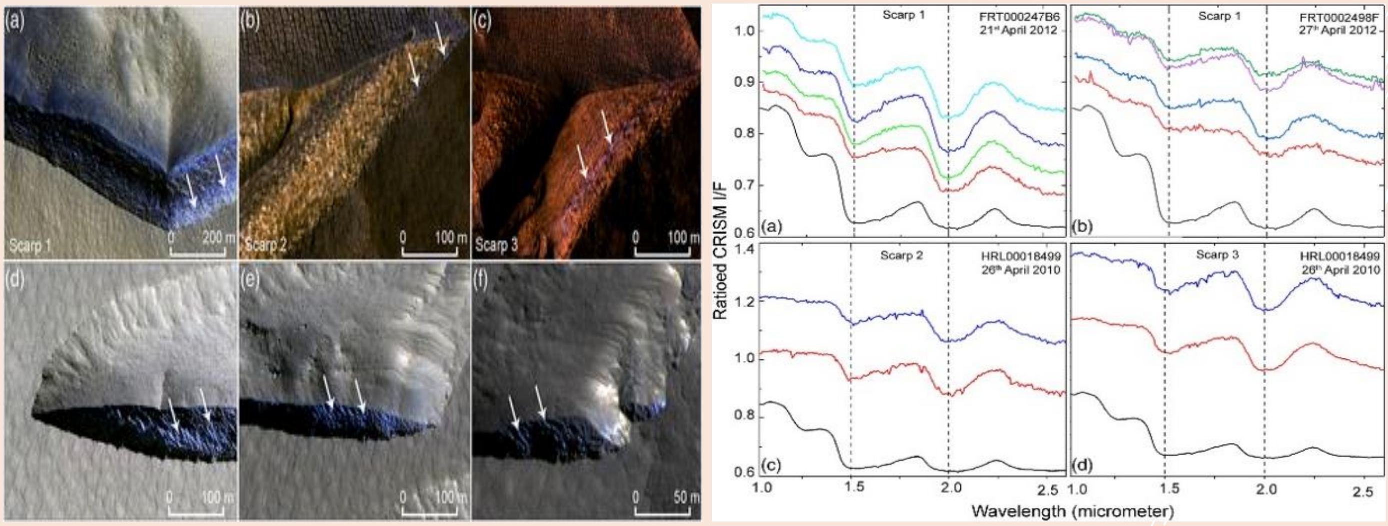


Figure caption: In left, false-colored HiRISE images with bluish-white contrast represent the water-ice-rich regions (a–c). (d)–(f) also show bluish-white color but no prominent water-ice spectra is observed. North is up, and sunlight is from the left in all figures. In right, CRISM spectrum (a) Spectrum for water ice from the scarp1. (b) Spectrum of water ice of the same scarp1 from 1-week temporal CRISM image. (c) Spectrum of water ice from scarp2. (d) Spectrum of water ice from scarp3. Black spectrum is the reference spectrum from MRO-CRISM spectral library.

Source: https://doi.org/10.1029/2020GL089057

Numerical modeling of the formation of Shackleton crater at the lunar south pole

(S. H. Halim, N. Barrett, S. J. Boazman, A. J. Gawronska, C. M. Gilmoure, Harish, K. McCanaan, A. V. Satyakumar, J. Shah, and D. A. Kring)

National Aeronautics and Space Administration (NASA) is planning for its next human landing in the south polar region of the Moon. The lunar south pole, on the rim of Shackleton crater, is the target for the next human landing on the Moon. We use numerical modeling to investigate the formation of that crater and the distribution of ejecta around the south pole. We find that a 1.5 km diameter asteroid with a chondrite-like composition, vertically impacting a gabbroic anorthositic target at 15 km/s, forms a crater morphologically similar to Shackleton. If the impact had a shallower 45-degree trajectory, the asteroid may have had a diameter of 1.75 km and velocity of 15 km/s or a diameter of 1.5 km and velocity of 20 km/s. Impact melt is generated during the impact, with most of the melt volume ponding on the crater floor. We introduce a water-bearing layer at various depths in the target and find that the burial depth of a water-ice bearing layer or volatile layer influences the final crater morphology and may explain the morphology of Shackleton

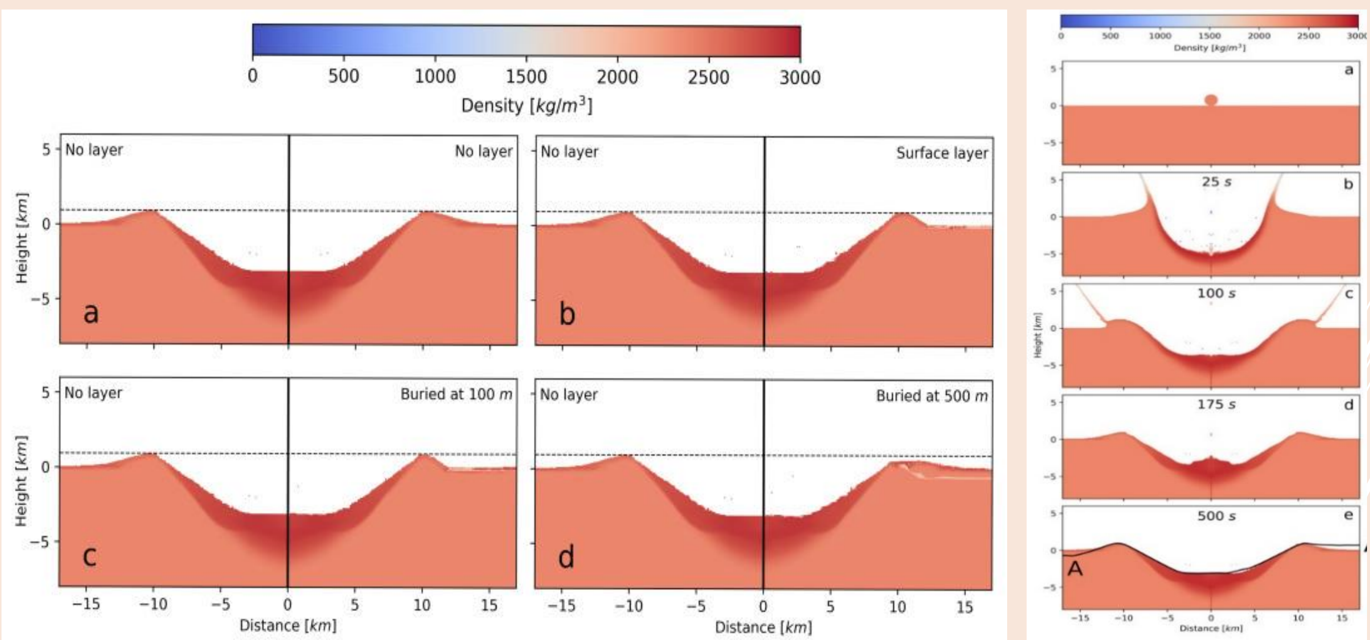


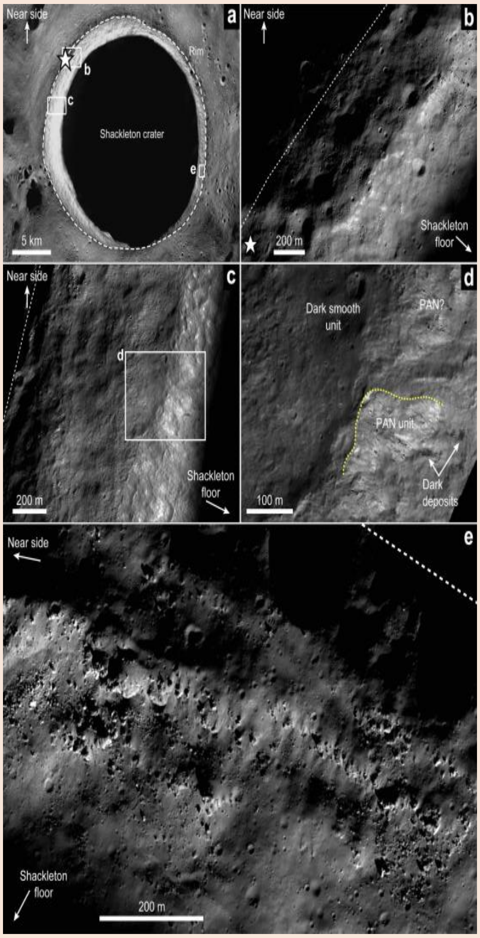
Figure caption: In left, density plot for the best-fit simulation for Shackleton crater, progressing from (a) the initiation of impact through to (e) 500 s post-impact. Black line in plot (e) shows a topographical profile of Shackleton crater. In right, comparative density plots for the final crater morphology of the best fit for Shackleton crater (left) against the same simulation with the introduction of a 100 m thick volatile layer (right) for each plot (a-d). Layer placement: (a) no layer, (b) on the surface, (c) buried at 100 m and (d) buried at 500 m. Dashed line shows the maximum height of the rim crest for the homogenous scenario (left).

Source: https://doi.org/10.1016/j.asr.2020.05.035

Geologic context and potential EVA targets at the lunar south pole *(A. J. Gawronska, N. Barrett, S. J. Boazman, C. M. Gilmoure, S. H. Halim, Harish, K. McCanaan, A. V. Satyakumar, J. Shah, H. M. Meyer, and D. A. Kring)*

The lunar south pole is the potential target for coming future missions to the Moon because it contains permanently shadowed regions (PSRs), which may sequester resources in the form of volatile materials. Additionally, it is being targeted for exploration, in part, because it contains topographical high points with >50% illumination needed for solar power. Geologically, the pole lies on the rim of ~21 km diameter Shackleton crater, which is located on the topographic rim of the ~2,500 km diameter South Pole-Aitken (SPA) basin, the largest and oldest basin on the Moon. To prepare for future missions, we conducted a photogeologic analysis of the walls, rim, and ejecta of Shackleton crater. Two types of underlying (target) terrains were identified. The impact penetrated and exposed (1) purest anorthosite (PAN) representative of primitive crust and (2) a layered terrain that is likely a series of impact ejecta deposits that stratigraphically cover the crystalline crust. Crew performing extravehicular activities (EVAs) near the south pole may be able to sample PAN; impact melt from Shackleton, SPA, and other pre-Nectarian and Nectarian-age impacts; and polar regolith, including material from small PSRs that may contain volatile components. The topography in the south polar region is dramatic, often producing slopes in excess of 15°, creating mobility challenges for astronauts during EVAs.

Source: https://doi.org/10.1016/j.asr.2020.05.035



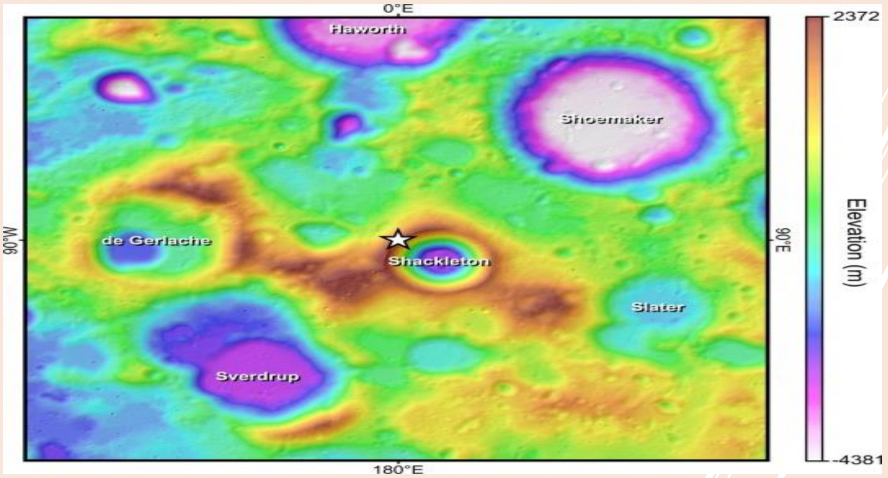


Figure caption: In left, Regional topographic map of the south polar region overlaid on hillshade. The white star denotes the location of the south pole. In right, (a) Averaged NAC mosaic showing the locations of images b, c, and e. The location of image d is shown in image c. The south pole is denoted by the white star. (b) NAC image showing the bright rock exposure of PAN identified in Yamamoto et al. (2012). These PAN rock exposures are ~500 m from the south pole. (c) NAC images showing blocks of PAN >500 m wide. The white box shows the location of image d. (d) A close-up image of the crater wall. (e) NAC image highlighting the layered stratigraphy in the inner wall of Shackleton crater opposite to the south pole.

Vishal Ng.

Invisible Higgs search through Vector Boson Fusion: A deep learning approach

Vishal S. Ngairangbam, Akanksha Bhardwaj, Partha Konar, and Aruna Kumar Nayak

After discovering the Higgs boson at the Large Hadron Collider (LHC), investigations are still going on to understand all its properties thoroughly, including its interaction with so-called "Dark Matter" (DM) particles. These exotic particles do not have electromagnetic interaction and cannot be observed in any telescopes. But they do interact gravitationally. Diverse evidence from astronomical and cosmological sources provide us with unambiguous evidence of such matter at different length scales of our Universe. More importantly, we are also capable of quantifying the amount as large as five times of our ordinary known form of the matter, made up of electrons, quarks, photons, or neutrinos! Interestingly if such "invisible" DM is produced at the LHC, we anticipate their presence from an imbalance of momentum at the detectors. Moreover, many background processes, many folds more extensive, mimic the same signature. This literally makes it similar to "finding a needle in a haystack"!

With the unique capability of machine-learning, especially deep-learning algorithms with neural networks, we have a tool at our hands capable of finding the proverbial needle. An incredibly powerful type of neural network is the Convolutional Neural Network (CNN), used commonly in image-based techniques like classification and segmentation. They have shown exceptional capabilities, overtaking humans in numerous circumstances. To use CNNs, we address the problem of finding the signal as a classification of images. We do this by using the analogy of the detectors to a camera. The spatial distribution of the energy essentially forms a picture with the energy deposits as the pixels' values. Using these so-called 'Tower Images,' we trained CNNs to identify signal type events from background ones. We were able to improve the existing upper bounds on the invisible-branching ratio of the Higgs by a factor of three using the same data. Such a tight constraint is even more impressive, given that we used the unprocessed low-level information directly from the detector, which is typically processed by our knowledge of physics first to derive these bounds.

Source/Reference of the Work: https://doi.org/10.1140/epjc/s10052-020-08629-w

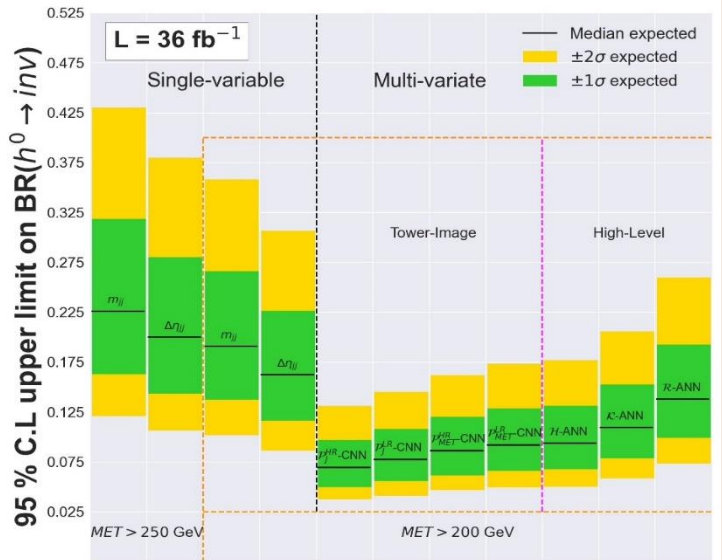


Figure Caption: Limits on the invisible branching ratio of the Higgs boson for the different analyses The first four columns are replication of existing techniques. The remaining columns show the comparison of various neural networks, the best one being the 5th one where there is best regularization of the orientation of events.

Science Highlights

Jayesh P. Pabari

Compact and high isolation microstrip diplexer for future radio scienceplanetary applications

(Trushit Upadhyaya, Jayesh Pabari, Varun Sheel, Arpan Desai, Riki Patel and S. Jitarwal)**Corresponding Author

A novel electrically compact and high isolation microstrip diplexer is engineered for Radio Occultation (RO) System for future planetary systems. The radio occultation technique is being utilized extensively in examining properties of a planetary atmosphere. A detection of shift in microwave signal is primary method to measure the occultation. The On-board RO transmitter utilizes the frequency synthesizers at two distinct frequency bands. The proposed microstrip diplexer has self-symmetrical structure that permits reduction in the trade-off between miniaturization and port isolation. The balanced geometry of two intrinsic filters permits several transmission zeros creating sharp edge, wider stopband and significant port isolation. The further tuning of the diplexer is possible without junction matching however; the insertion loss and isolation may vary based on the frequency shift. The electrical size of the proposed diplexer is $0.52\lambda \times 0.625\lambda$ at lower frequency. The optimized structure provides fraction bandwidth of around 4.6% at 6.7 GHz and 4.34% at 8.4 GHz frequencies. The isolation is better than 27 dB for both frequencies. The validation of simulated results is carried out through measurements on fabricated prototype.

Source/Reference of the Work: https://doi.org/10.1016/j.aeue.2020.153497

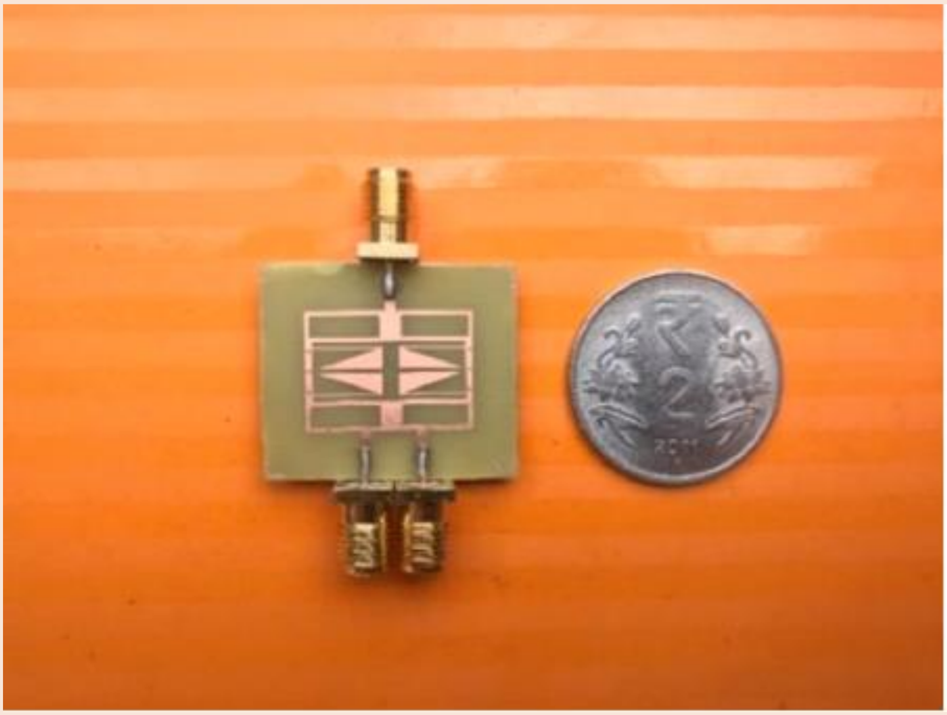


Figure Caption: Fabricated Diplexer.

Prithish Halder

Modelling heterogeneous dust particles. An application to cometary polarization

Prithish Halder & Shashikiran Ganesh

Cometary dust particles are some of the pristine materials present in our solar system. They hold primordial signatures of the physical processes that led to their formation in the solar proto-planetary disk. In this work, we introduce a comet dust model to study the polarimetric response from a wide variety of morphologically different dust particles revealed by the *Rosetta* spacecraft from the comet 67P/Churyumov-Gerasimenko. The flexibility of the model, allows us to control a large number of physical parameters like size, shape, porosity and composition of the dust particles. This enables us to replicate the standard polarization phase curve observed in several comets having different dynamical age. Apart from the polarimetric response, the model also recreates the strong wavelength dependence of polarization observed in the case of comet Hale-Bopp. Our dust model indicates that long-period comets may have a high percentage of loose particles, retaining the morphology from the proto-planetary phase, while the short-period comets possess a high percentage of solid particles with low porosity. This difference in the dust properties could be due to frequent and/or higher magnitude of weathering by solar radiation during the relatively more frequent passages close to the Sun by the short-period comets. This computational simulation extensively used the Vikram-100 HPC.

Source: https://doi.org/10.1093/mnras/staa3647

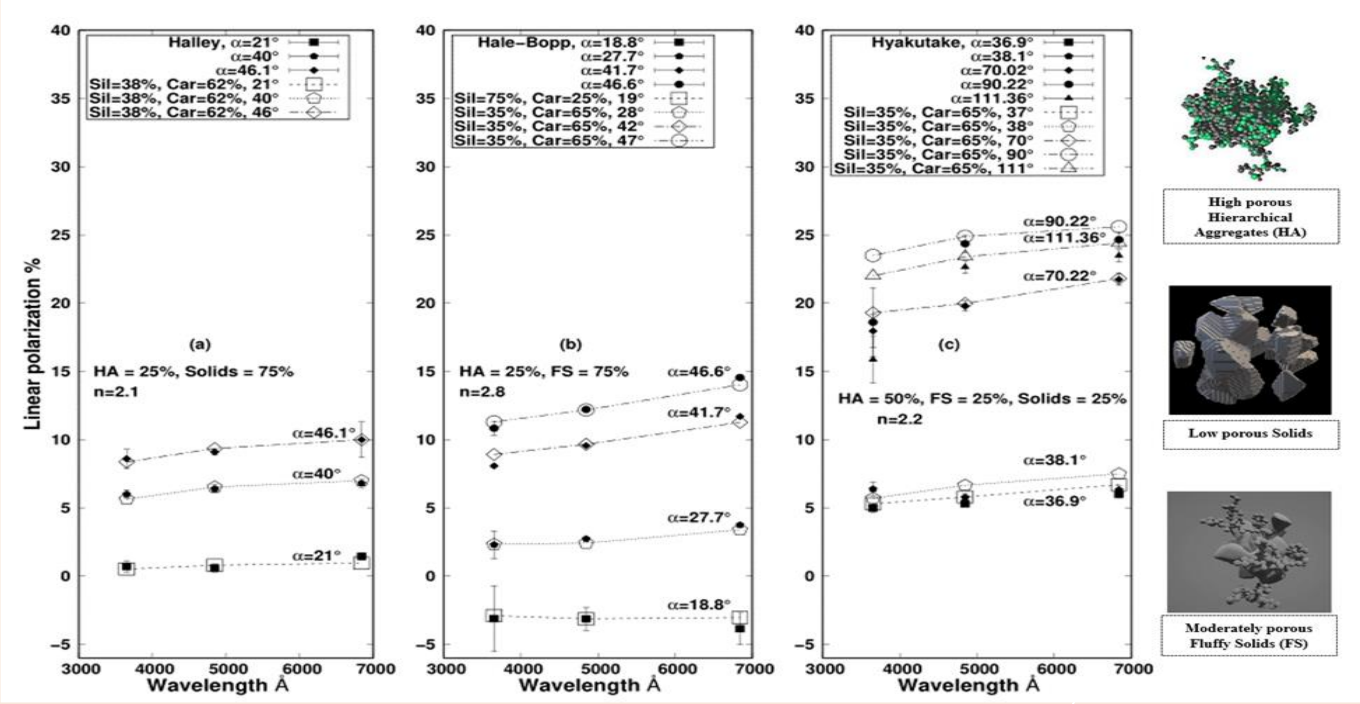
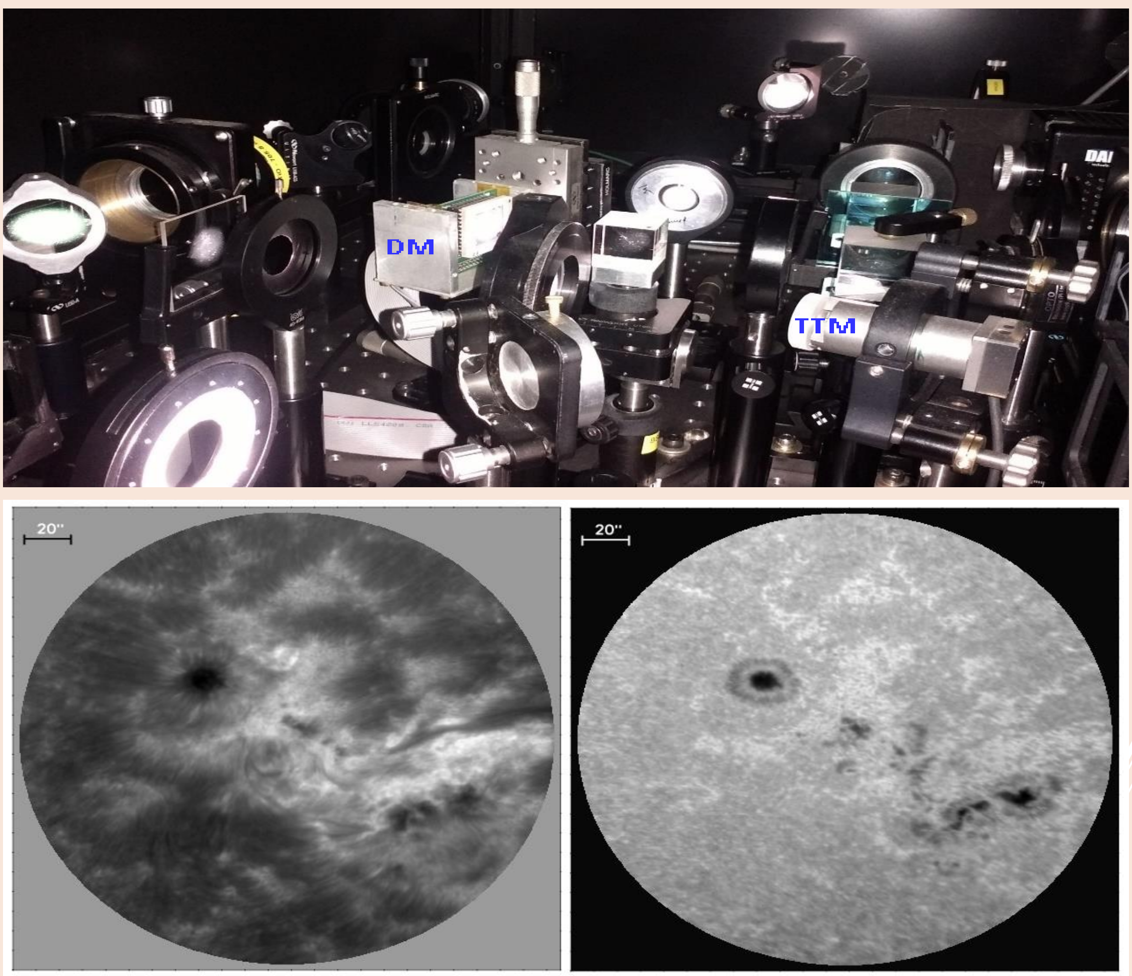


Figure: The best fit wavelength dependence of polarization for comet 1P/Halley (a), C/1995 O1 (Hale-Bopp) (b) & C/1996 B2 (Hyakutake) (c) from the model data (hollow shapes) with the observed data (filled shapes)

MAST Observations with the Adaptive Optics System and Narrow-band Imager

The Adaptive Optics (AO) system at the 50 cm Multi-Application Solar Telescope (MAST) of USO-PRL is presently providing a stable and aberration-corrected light beam to the post-focus instruments, thus allowing acquisition of high-resolution observations with a superior image quality. The AO system comprises a tip-tilt mirror and a 37-actuator membrane mirror for global- and local-tilt correction, respectively (see top panel), operating at an update rate of around 900 Hz. The corrected wavefront from the AO system is fed to the Fabry-Perot-based Narrow-band Spectral Imager which acquires filtergrams in the chromosphere (Ca II @ 854.2 nm) and photosphere (Fe I @ 617.3 nm), simultaneously (see bottom panel). This technological demonstration brings MAST into an elite club of high-resolution, ground-based, solar telescopes.



Top: Optical setup of the AO system showing the Tip-Tilt mirror (TTM) and the Deformable Mirror (DM). **Bottom:** Observations of NOAA active region 12781 obtained with Narrow-band Spectral Imager on MAST with the AO system in closed-loop operation on 2020 November 9. The field-of-view is 236×236 arcsec^2. The left and right panels correspond to the line core images in the Ca II 854.2 nm spectral line and Fe I 617.3nm spectral line, respectively that form in the chromosphere and photosphere, respectively. The line scan range for the two wavelengths are ±1 nm and ±0.4 nm, respectively with exposure times of 200 ms and 70 ms.

Events and Activities

Celebration of Constitution Day at PRL on 26th November, 2020

The Government of India has decided that "Constitution Day" would be celebrated every year on 26th November to commemorate the adoption of the Constitution of India and to honour, acknowledge the contribution of the Founding Fathers of the Constitution. Accordingly, as per the directives received from Department, November 26, 2020, Thursday was observed as "Constitution Day" at PRL, Ahmedabad.

On this occasion, all staff members were requested to read the "PREAMBLE" of the Constitution on 26.11.2020 (Thursday) at 11:00 AM at their respective work place to inculcate the basic awareness and obligations as a Citizen.

It was observed that all the staff members participated enthusiastically in reading the "PREAMBLE" of the Constitution from their own work place and a feeling of Patriotism was felt by them. Besides this the "PREAMBLE" of the Constitution was displayed near entry Area of PRL Campus for attention of all Employees/Visitors.

Due to Covid-19, the reading of "PREAMBLE" of the Constitution in person was restricted up to the Senior Officers which was attended by our Director Dr. Anil Bhardwaj, Registrar, Mr. Chavali VRG Deekshitulu and Dean, Prof. (Dr.) Pallam Raju who all encouraged staff members to actively participate from their own work place in reading "PREAMBLE" of the Constitution and had enlightened the importance of event with their gracious presence.

Similarly, "PREAMBLE" of the Constitution was also read by all our staff members at one's own work place who are based at our Thaltej Campus, Udaipur Solar Observatory (USO), Udaipur and Infrared Observatory at Mt. Abu Offices.

Vigilance Awareness Week 2020

The ‘Vigilance Awareness Week 2020" was observed in Physical Research Laboratory, Ahmedabad from 27.10.2020 to 02.11.2020 and the Vigilance Awareness Pledge has been undertaken by the staff members of PRL on 27.10.2020 through Online at one’s respective place. The banner and various pamphlets with regard to Vigilance Awareness were displayed at prime location of Physical Research Laboratory, Ahmedabad. An essay writing competition on this year theme “Satark Bharat, Samriddh Bharat (Vigilant India, Prosperous India)” as a part of vigilance awareness week was also organized on 29.10.2020. Besides, 87 Employees of PRL have been registered for e-Pledge in the CVC portal.

Awards and Honours

The following PRL faculty members are listed in the list of ***Top 2% of Scientists in the world in their respective fields*** published by Stanford University.

1. Prof. B K Sahoo, Professor, Atomic, Molecular and Optical Physics Division.

2. Prof. S. Ramachandran, Senior Professor, Space and Atmospheric Sciences Division.

3. Prof. M. M. Sarin, Senior Professor, (Retd.), Geosciences Division.

4. Prof. A. S. Joshipura, Outstanding Scientist, (Retd.), Theoretical Physics Division.

5. *Late Prof. N. N. Rao*, Theoretical Physics Division.

The PRL family heartily congratulate Prof. Sahoo, Prof. Ramachandran, Prof. Sarin, and Prof. Joshipura on this recognition and wish them continued success in their professional endeavours.

Colloquia @ PRL

Dr. Dibyendu Chakrabarty (Associate Professor, SPASC Division, PRL) delivered a colloquium entitled “Space weather: From anomaly to insights.” On 04 November 2020.

Dr. Satyajit Seth (Assistant Professor, THEPH Division, PRL) delivered a colloquium entitled “Precision @ LHC” on 11 November 2020.

Dr. Lokesh Kumar Dewangan (Assistant Professor, A&A, Division, PRL) delivered a colloquium entitled "New insights into the formation of massive stars." on 18 November 2020.

Dr. Girjesh R. Gupta (Assistant Professor, USO, PRL delivered a colloquium entitled “Role of waves and small-scale transients in the coronal heating” on 25 November 2020.

The Editorial Team


Bijaya Sahoo


Rohan Louis


Prashant Jangid


A.Shivam


Partha Konar


Garima Arora


Pragya Pandey


Deekshya Sarkar

Physical Research Laboratory
Ahmedabad - 380009
India

भौतिक अनुसंधान प्रयोगशाला
अहमदाबाद-380009
भारत

https://www.prl.res.in/prleng/newsletter
Contact: newsletter@prl.res.in