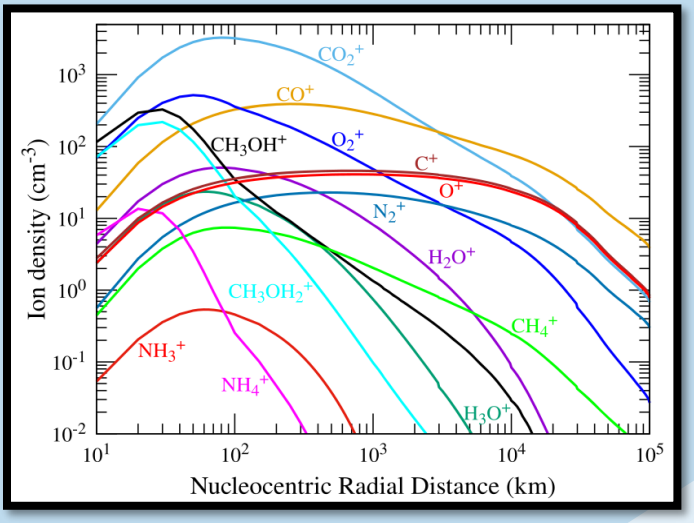
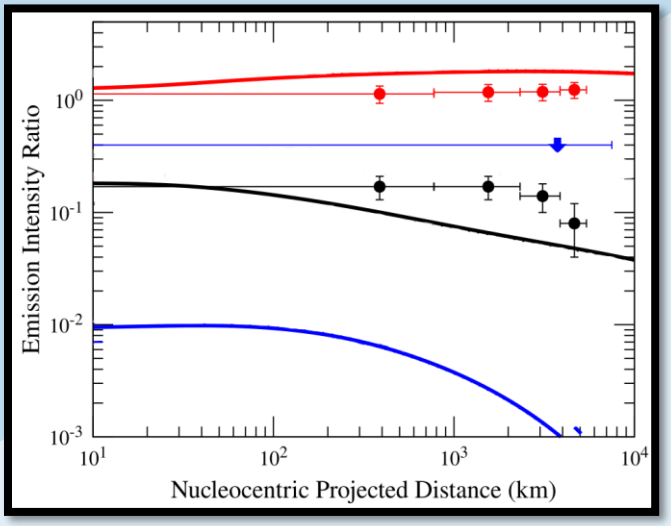
# PRL News – *The Spectrum*

MONTHLY NEWSLETTER OF THE PHYSICAL RESEARCH LABORATORY


## WHAT'S INSIDE?

# Sputtering of Presolar Grains via Galactic Cosmic Rays in the Interstellar Medium

*(Akshat Garg, Kuljeet K. Marhas, and Vikram Goyal)*

VIKRAM GOYAL

The sputtering rate of presolar silicon carbide grains due to galactic cosmic rays has been computed for their experimentally deduced lifetimes (~1 Gyr) in the interstellar medium. An ion target simulator, SDTrimSP, was used to model the sputtering of interstellar grains with varying sizes and thicknesses of the ice mantle formed around the grain during their journey through the interstellar medium. Temperature, composition and density for four different types of molecular cloud environments (quiescent, low-mass young stellar objects (YSOs), intermediate-mass YSOs, and high-mass YSO weak processing) ELIAS 16, ELIAS 29, R CrA IRS1, and ORION IRc2 respectively, are considered to indicate the sputtering rate on the mantle ice composition depends on water composition to a certain extent. The model simulations indicate galactic cosmic ray(s) with an energy range from 10 MeV to 1 GeV are just capable of sputtering/destructing ~13%–15% of the grain itself. This value, stretched over 1 Gyr, is not as significant as the other destruction processes and can be classified as a minor destruction process. The effect of galactic cosmic rays on the ice mantle and core is also noted, emphasising amorphisation/recoils generated inside the SiC core and their distribution within the grain.

https://doi.org/10.3847/1538-4357/abc25b

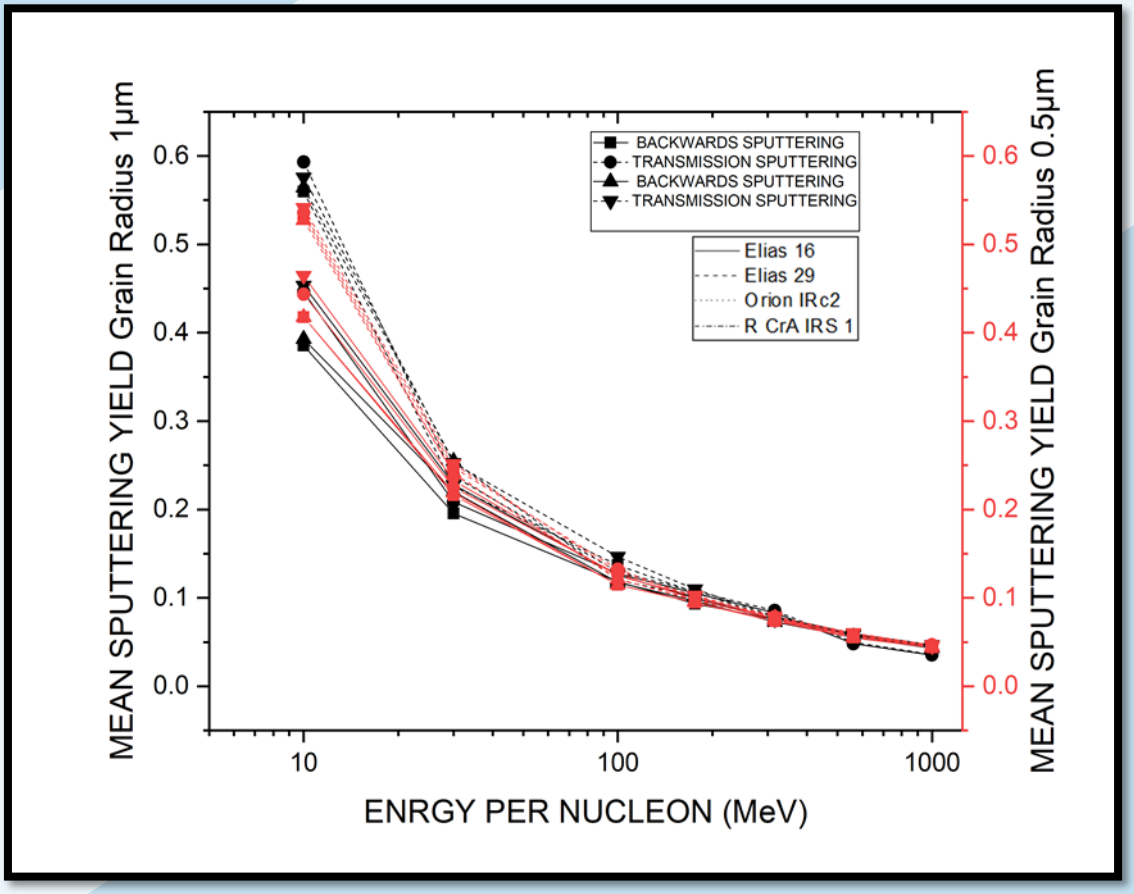



Figure Caption: Plot comparing backward sputtering and transmission sputtering at different energies for all four sources for grain having radius (a) 1 µm (shown in black symbols) and (b) 0.5 µm (shown in red symbols).

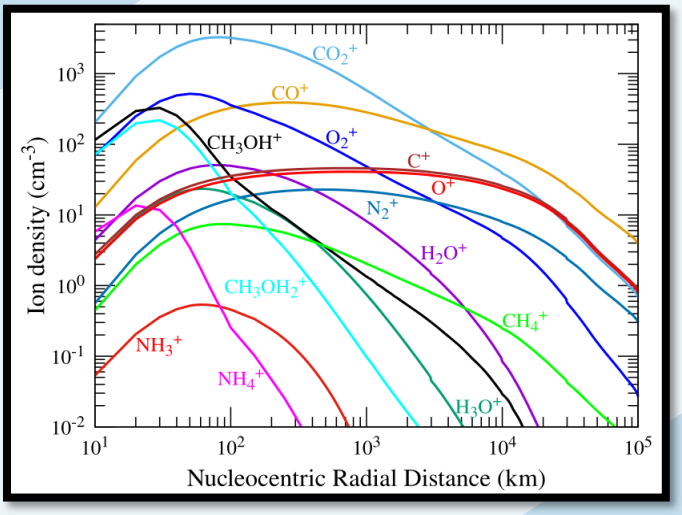
# A PHYSICO - CHEMICAL MODEL TO STUDY THE ION DENSITY DISTRIBUTION IN THE INNER COMA OF COMET C/2016 R2 (PAN-STARRS)

*(Susarla Raghuram, Anil Bhardwaj, Damien Hutsemékers, Cyrielle Opitom, Jean Manfroid, and Emmanuel Jehin )*

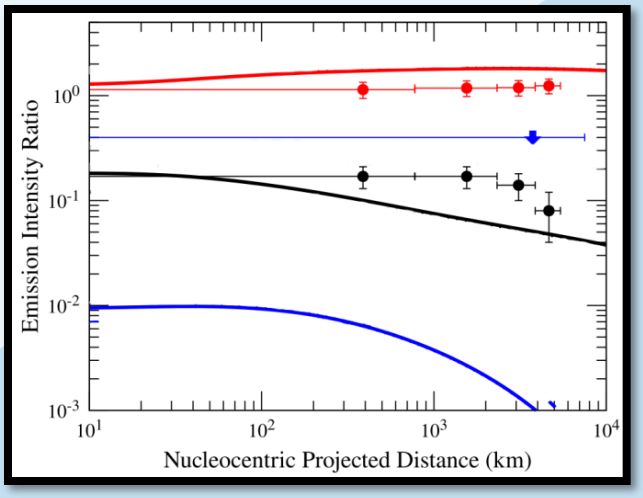
SUSARLA RAGHURAM

The recent observations show that comet C/2016 R2 (Pan-Starrs) has a unique and peculiar composition when compared with several other comets observed at 2.8 au heliocentric distance. We developed a physico-chemical model to study the ion density distribution in the inner coma of this comet by accounting for photon and electron impact ionization of neutrals, charge exchange and proton transfer reactions between ions and neutrals, and electron–ion thermal recombination reactions. Our calculations show that $CO_2^+$ and $CO^+$ are the major ions in the inner coma, and close to the surface of nucleus $CH_3OH^+$, $CH_3OH_2^+$, and $O_2^+$ are also important ions. By considering various excitation sources, we also studied the emission mechanisms of different excited states of $CO^+$, $CO_2^+$ , $N_2^+$, and $H_2O^+$. We found that the photon and electron impact ionization and excitation of corresponding neutrals significantly contribute to the observed ionic emissions for radial distances smaller than 300 km and at larger distances, solar resonance fluorescence is the major excitation source. Our modelled ion emission intensity ratios are consistent with the ground-based observations. Based on the modelled emission processes, we suggest that the observed ion emission intensity ratios can be used to derive the neutral composition in the cometary coma only when the ion densities are significantly controlled by photon and photoelectron impact ionization of neutrals rather than by the ion–neutral chemistry.

doi:10.1093/mnras/staa3885




The modelled ion density profiles in comet C/2016 R2.




Modelled emission intensity ratios of N2+/CO (red), CO2+/CO+ (black), and H2O+/CO+ (blue) as a function of projected distance. Solid curves are the modelled ratio profiles by accounting for all the excitation sources. The observed flux ratios are plotted with corresponding colours with vertical error bars. The blue horizontal line with a downward arrow represents the derived upper limit of H2O+/CO+ emission intensity ratio.

# Evolutionary stages and triggering process of a complex eruptive flare with circular and parallel ribbons

*(Navin C. Joshi, Bhuwan Joshi and Prabir K. Mitra)*

Prabir Mitra

We report multiwavelength study of a complex M-class solar eruptive flare that consists of three different sets of flare ribbons, viz. circular, parallel, and remote ribbons. Magnetic field modeling of source active region NOAA 12242 exhibits the presence of 3D null-point magnetic topology that encompasses an inner bipolar region. The event initiates with the faint signatures of the circular ribbon along with remote brightening right from the pre-flare phase that points toward the ongoing slow yet persistent null-point reconnection.

With the onset of M8.7 flare, there is a substantial enhancement in the brightening of circular ribbon, which essentially suggests an increase in the rate of ongoing null-point reconnection. Finally, the eruption of underlying flux rope triggers 'standard flare reconnection' beneath it producing an abrupt rise in the intensity of the parallel ribbons as well as enhancing the rate of null-point reconnection by external forcing. We show that within the fan dome, the region with magnetic decay index n>1.5 borders the null-point QSL. Our analysis suggests that both the torus instability and the breakout model have played role toward the triggering mechanism for the eruptive flare. This event is a nice example of the dynamical evolution of a flux rope initially confined in a null-point topology that subsequently activates and erupts with the progression of the circular-cum-parallel ribbon flare.

doi:10.1093/mnras/staa3480

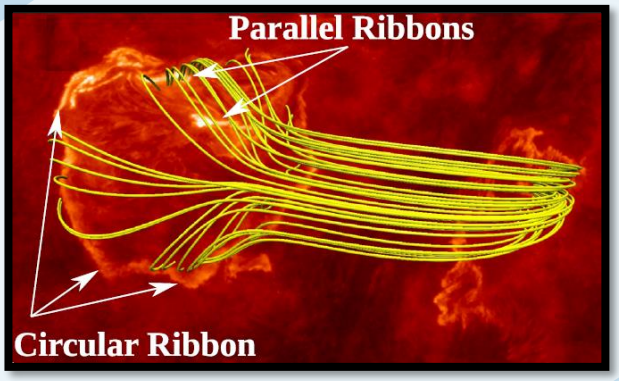



Figure 1: SDO/AIA 304 Å image showing the evolution of different sets of flare ribbons, overplotted with the NLFFF extrapolated field lines (shown in yellow color).

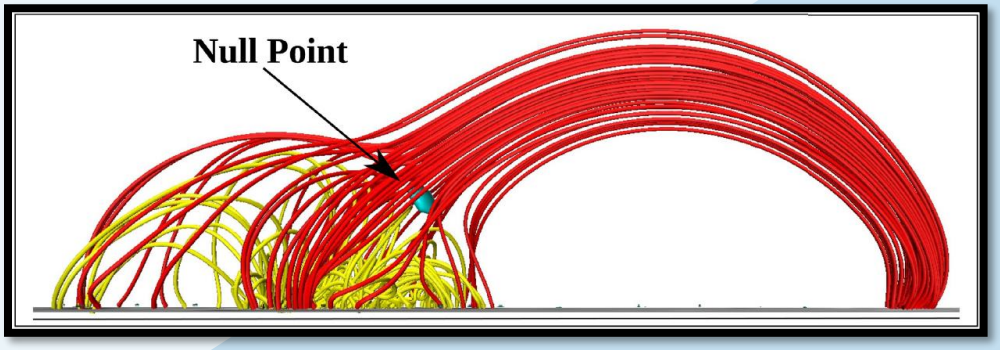



Figure 2: Fan-spine coronal magnetic configuration associated with the flaring activity. The cyan-colored patch between yellow and red lines indicate the location of a coronal null point.

# Forbidden atomic oxygen emissions in the Martian dayside upper atmosphere

*(Susarla Raghuram, Sonal Kumar Jain, and Anil Bhardwaj)*

SUSARLA RAGHURAM

Recently, Nadir and Occultation for Mars Discovery (NOMAD) ultraviolet and visible spectrometer instrument on board the European Space Agency's ExoMars Trace Gas Orbiter (TGO) simultaneously measured the limb emission intensities for both [OI] 2972 and 5577 Å (green) emissions in the dayside of Martian upper atmosphere. But the atomic oxygen red-doublet emission lines ([OI] 6300 and 6364 Å), which are expected to be observed along with [OI] 5577 and 2972 Å emissions, are found to be absent in the NOMAD-TGO dayside observed spectra. We aim to explore the photochemistry of all these forbidden atomic oxygen emissions ([OI] 2972, 5577, 6300, 6464 Å) in the Martian daylight upper atmosphere and suitable conditions for the simultaneous detection of these emissions lines in the dayside visible spectra. A photochemical model is developed to study the production and loss processes of $O(^1S)$ and $O(^1D)$, which are the respective excited states of green and red-doublet emissions, by incorporating various chemical reactions of different O-bearing species in the upper atmosphere of Mars. By reducing Fox (2004) modelled neutral density profiles by a factor of 2, the calculated limb intensity profiles for [OI] 5577 and 2972 Å emissions are found to be consistent with the NOMAD-TGO observations. We studied various parameters which can influence the limb intensities of these atomic oxygen forbidden emission lines. Our calculated limb intensity for [OI] 6300 Å emission, when the Mars is at near perihelion and for solar maximum condition, suggests that all these forbidden emissions should be observable in the NOMAD-TGO visible spectra taken on the dayside of Martian upper atmosphere. More simultaneous observations of forbidden atomic oxygen emission lines will help to understand the photochemical processes of oxygen-bearing species in the dayside Martian upper atmosphere.

doi.org/10.1016/j.icarus.2021.114330

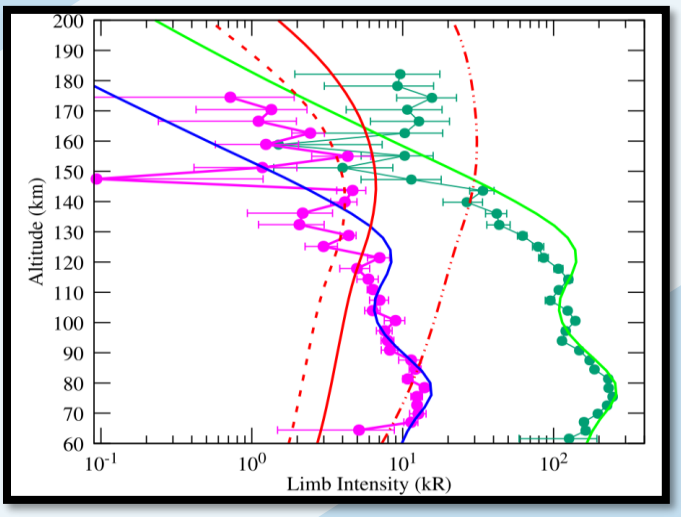



Figure Caption: Comparison between modelled and NOMAD-TGO observed limb intensity profiles of [OI] 2972, 5577, and 6300 Å emissions. Magenta and thick green curves with x-error bars represent the respective observed limb intensity profiles for [OI] 2972 and 5577 Å emissions on 28 April 2019. Blue, green and red curves are the modelled limb intensity profiles for [OI] 2972, 5577 and 6300 Å emissions, respectively. For more details refer the publication

# Homologous Flaring Activity over a Sunspot Light Bridge in an Emerging Active Region

*(Rohan Eugene Louis and Julia K. Thalmann)*

ROHAN LOUIS

Sunspot light bridges are known to exhibit a variety of dynamic and persistent phenomena such as surges, small-scale jets, etc., in the chromosphere and transition region. While it has generally been proposed that magnetic reconnection is responsible for this small-scale dynamism, persistent flaring activity lasting several hours from the same spatial location on a sunspot light bridge has rarely been reported. We combine observations from the Atmospheric Imaging Assembly and the Helioseismic Magnetic Imager on board the Solar Dynamics Observatory to investigate homologous flaring activity over a small sunspot light bridge in an emerging flux region. The homologous flares all produced broad, collimated jets, including a B6.4 class flare.

The jets rise at a speed of about 200 km/s and emerge from the same spatial location for nearly 14 hrs, after which they cease completely. A nonlinear force-free (NLFF) extrapolation of the photospheric magnetic field shows a low-lying flux rope connecting the light bridge to a remote opposite-polarity network. The persistent flares occur as a result of the rapid horizontal motion of the leading sunspot that causes the relatively vertical magnetic fields in the adjacent umbra to reconnect with the low-lying flux rope in the light bridge. Our results indicate that the flaring ceases once the flux rope has lost sufficient twist through repeated reconnections.

https://iopscience.iop.org/article/10.3847/2041-8213/abd478

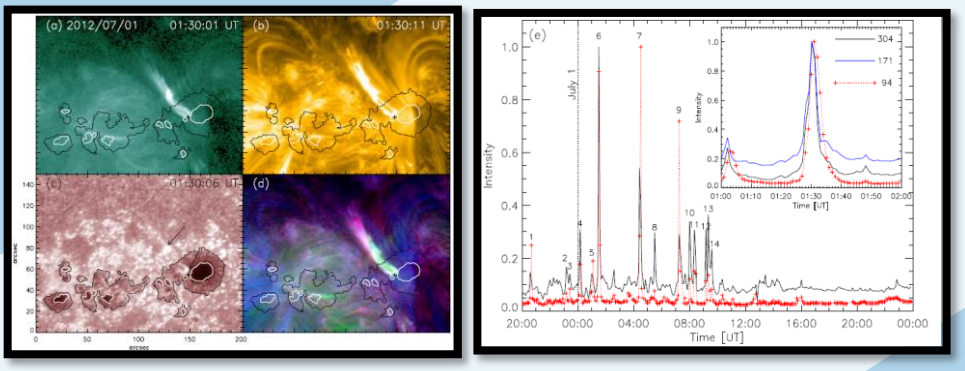



Figure Caption: B6.4 flare in the leading sunspot of NOAA AR 11515. Panels (a), (b), and (c) correspond to AIA 94 Å, 171 Å, and 1700 Å channels, respectively. Panel (d) is a color composite image made from the AIA 304 Å (red), 94Å (green), and 171 Å (blue) channels. The black plus symbol indicates the base of the jet on the LB. Panel (e) shows the mean intensity extracted from the contour outlining the jet. The inset shows the light curve around *the* time of the B6.4 flare.

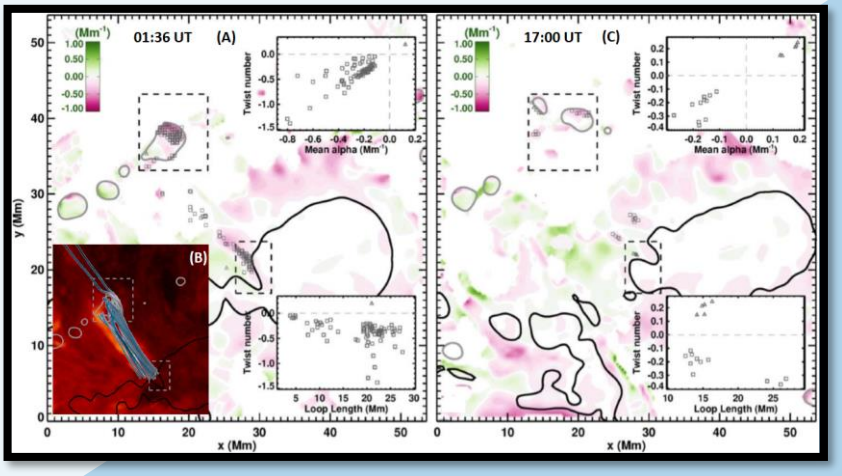



Figure Caption: Force-free and twist parameter at 01:36 UT (A) and 17:00 UT (C). Dashed outlines at x,y=15, 38 Mm and x, y = 28,21 Mm outline the moat area and LB in the leading sunspot, respectively, from which field lines were computed. The color-coded background shows the force-free parameter α. The insets show the twist of the field lines as a function of α and the loop lengths of the field lines. Panel B shows the NLFF modeling of the coronal magnetic field covering the connectivity of the observed LB and the moat area at 01:36 UT.

# REPUBLIC DAY CELEBRATIONS

The **72nd Republic Day** was celebrated in all its solemnity and grandeur at PRL on 26th January 2021. Dr. Anil Bhardwaj, Director, PRL hoisted the national flag clock with a General Salute by the CISF personnel. He inspected the Guard of Honour presented by CISF personnel. After that, he briefed the audience about the activities, achievements, honours etc. acquired by PRL during the year. He also presented awards to CISF Personnel for their exceptional services and distributed the prizes to the winners of essay competition conducted during Vigilance Awareness Week celebrated at PRL.At last, he extended his warm wishes to all staff members and their family on the auspicious occasion. Staff members attended the programme by strictly following the COVID-19 guidelines.

The Republic Day was also celebrated at USO with Prof. Nandita Srivastava hoisting the National Flag. The runners-up and winners from the Badminton Tournament, organized by the USO-SWC on 8th March 2020, were also awarded on the occasion with Prof. Shibu Mathew and Prof. Nandita Srivastava handing out the trophies.

# Pension Adalat held at PRL

As per the directives of Department of Pensions and Pensioners' Welfare, New Delhi and Department of Space, Bangalore, a Pension Adalat was held on Tuesday, the 19th January 2021 at PRL, Ahmedabad through online mode for addressing various Pension related grievances.

7 Pensioners of PRL had attended the Pension Adalat. The Adalat was conducted by Shri Anand D Mehta, Head, P&GA, Shri Suresh Babu A, Head, Accounts & IFA and Shri Senthil Babu, Sr.AO (Establishment). The grievances/suggestions of Pensioners were heard and noted for early resolution.

The pension Adalat was ended with vote of thanks by Head, P&GA.

# Colloquia

- **Prof. Ravi Shankar Nanjundiah** *(Director, Indian Institute of Tropical Meteorology, Pune)* delivered an online colloquium entitled ***"Variability of Monsoons at Different Scales"*** on 06 January 2021.
- **Prof. Mohit Randeria** *(Professor, The Ohio State University, Columbus, United States)* delivered a special colloquium entitled ***"Are there Upper Bounds on the Superconducting Transition Temperature?"*** on 13 January 2021.
- **Dr. Mrutyunjay Mohapatra** *(Director General of Meteorology (DGM),* India Meteorological Department (IMD), New Delhi) delivered an online colloquium entitled ***"Weather Forecasting in India: Current status and future plan"*** on 20 January 2021.
- **Prof. Praveen Nahar** *(Director, National Institute of Design (NID), Ahmedabad)* delivered an online colloquium entitled ***"Design Thinking and Innovation"*** on 27 January 2021.

# Awards and Honours

- **Prof. S. Ramachandran** (Senior Professor, SPASC Division, PRL) has been made an *"Affiliate Scholar" of the Institute for Advanced Sustainability Studies (IASS)*, Potsdam, Germany by the Board of Directors of the IASS.
- **Dr. Arvind Singh** (Associate Professor, Geosciences Division, PRL) has been selected for the *Krishnan medal of IGU (Indian Geophysical Union)* for the year 2020 and has also been selected for the *membership in the Indian National Young Academy of Sciences (INYAS)* for a period of 5 years beginning February 2021.

**WE CONGRATULATE ALL THE PRL MEMBERS FOR THEIR WELL-DESERVED HONORS AND WISH THEM ALL THE BEST FOR THEIR FUTURE ACHIEVEMENTS**

# Hearty Welcome to New Members

Lovejeet Meena
Technical Assistant

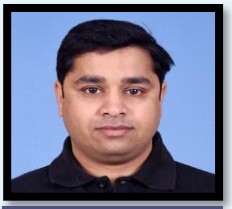
Sandeep Manglani
Jr. Personal Assistant

# Obituary

| Late Shri M.V. Bhavsar<br>Technical Assistant-E | |
|---|---|
| Date of Birth | 22.12.1937 |
| Date of retirement | 31.12.1997 |
| Date of Death | 04.12.2020 |

We mourn the demise of our former employee and fondly remember his contributions to PRL. We pray for the well-being of the bereaved family. May the departed souls rest in peace.

# The Editorial Board



Bijaya Sahoo

Partha Konar

Pragya Pandey

Garima Arora

A. Shivam

Deekshya Sarkar

Prashant Jangid

Rohan Louis