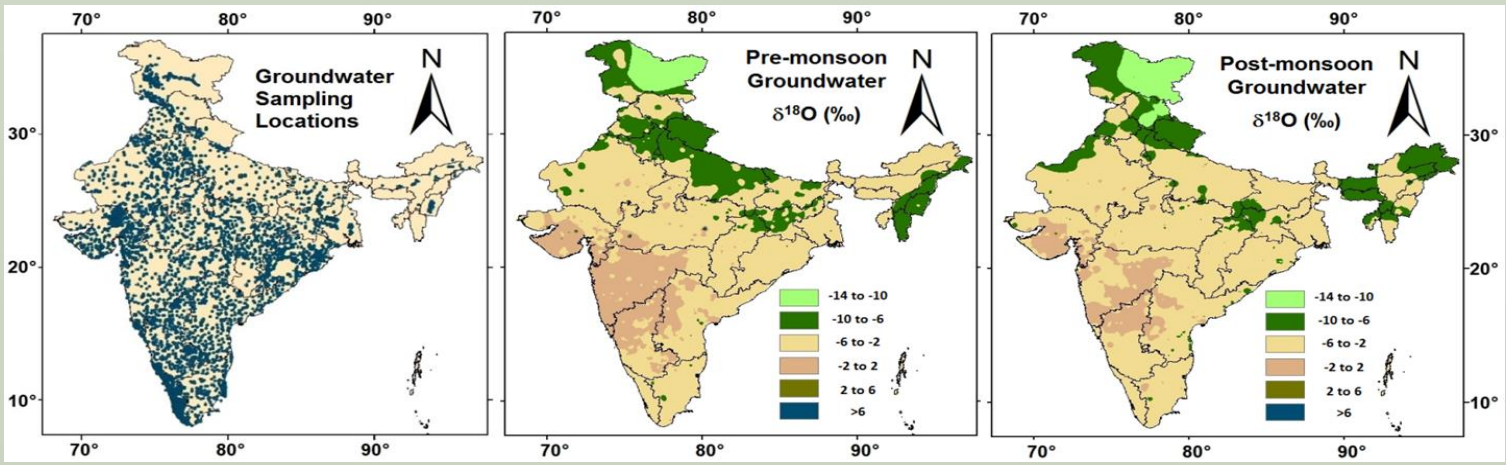
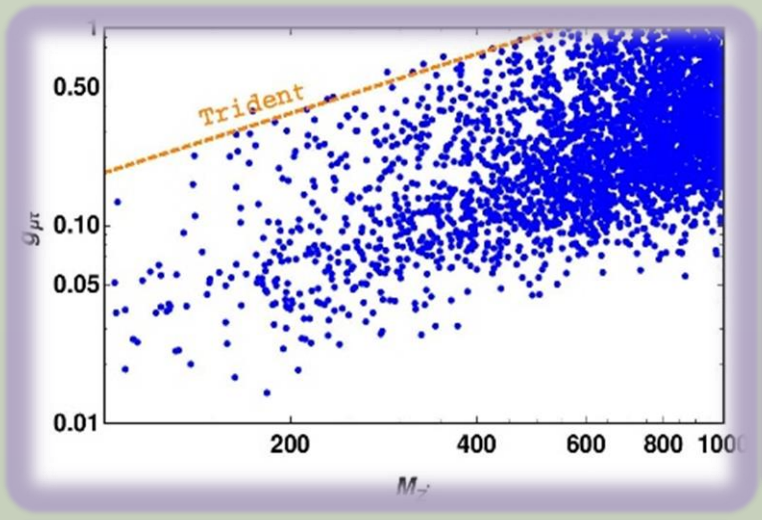
PRL News – The Spectrum

April 2019





Physical Research Laboratory
Ahmedabad - 380009
India

भौतिक अनुसंधान प्रयोगशाला
अहमदाबाद-380009
भारत

Website: https://www.prl.res.in/prl-eng/newsletter

Contact us: newsletter@prl.res.in

Hydrological Problems of India: Importance of Isotope Applications

R.D. Deshpande

Water is one of the most essential substance for survival of life on earth. Socio-economy of any country is strongly dependent on availability of water and its efficient utilization to meet ever-increasing demand for agricultural, industrial, domestic and livestock usage. Providing required quantity and quality of water at right time, at right place, is the biggest challenge for any fast-developing country such as India. Distribution of water also has strong political dimension because it affects agriculture, industry and service sectors of socio-economy, and concerns all citizens. Water related disputes range from a small residential colony to international trans-boundary levels.

Unfortunately, India is fast running out of water due to pollution, over-extraction and climate change. India has lost significant part of its major surface water sources due to pollution and encroachment. Due to its lower capital cost and ubiquitous presence, groundwater is the most preferred source of water in India. Therefore, the total volume of groundwater extracted in India per year (~ 250 km^3/yr) is the highest in the world. The rate of increase in groundwater extraction is also very high in India as a result of which groundwater resources are dwindling rapidly.

In addition to excessive extraction of groundwater and imminent scarcity, there is a rapid deterioration of groundwater quality due to geogenic and anthropogenic contaminants. Besides widespread and commonly known contaminants in water such as fluoride, arsenic, nitrate and pesticides, there are other contaminants such as iron, uranium, manganese, zinc, chromium, selenium, mercury and cadmium in localized areas, known for their adverse health effects for human and cattle population. In addition to these well-known contaminants of water, a new generation of emerging pollutants of synthetic and natural origin have also been recently recognized as newer environmental and health hazards.

Besides its importance for consumptive utilization by human and other life forms, water also affects several natural processes such as: (i) various natural cycles (e.g. hydrological cycle, carbon cycle, nitrogen cycle etc), (ii) nutrient and heat transportation in oceans, (iii) atmospheric radiation budget and heat transfer, (iv) weathering, soil formation and landform evolution, (v) meteorology and weather systems, and (vi) ecology and environment. Therefore, any change in natural hydrological system practically affects every other natural system.

The global hydrological cycle is broadly influenced by three major drivers, namely: (i) anthropogenic climate change due to emission of greenhouse gases and aerosol, (ii) engineered interventions (dams, weirs, bunds, canals, pipelines, infiltration wells) for storage and transportation of water to meet the growing water demand, and (iii) long term natural climate variability. Various hydrological systems take a finite time to respond to these drivers. Consequently, there is considerable uncertainty and knowledge gap about hydrological response to these drivers in near future (decades) and on longer time scales (centuries).

In the above discomforting scenario of hydrological problems, the most important point to be realised is that major policy decisions about water resources development and management should be based on strong scientific understanding about its immediate and long-term consequences, derived from a large and densely spaced

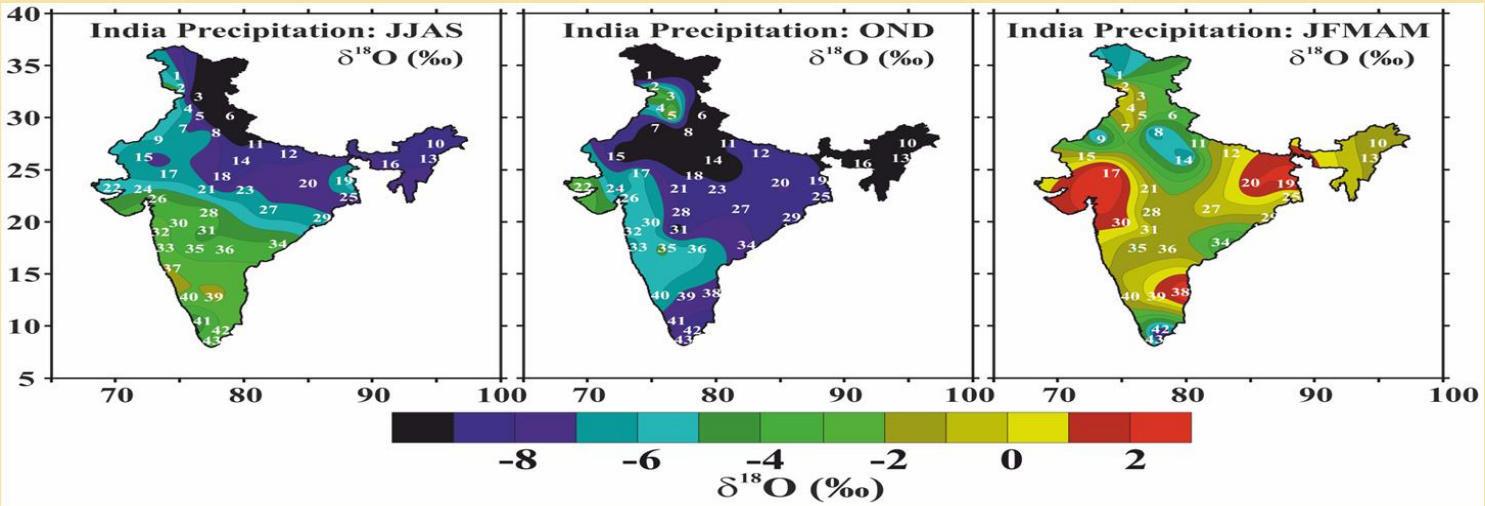


Figure 1: Map of seasonal average oxygen isotopic composition of precipitation samples collected at 43 locations across India. Spatial and temporal variation in isotopic composition can be interpreted in terms of region specific hydrometeorological processes and vapour source variation.

observations. For this, it is necessary to closely monitor the contemporary hydrological cycle and understand various subtle processes operating at different spatiotemporal scales and the linkages between seemingly unrelated factors.

The conventional hydrometric approach of measuring volumes of water in different hydrological components (underground, surface and atmospheric) and fluxes across real or perceived boundaries separating these components cannot provide information about the physics underlying various processes, and interaction and exchange of mass and energy between different hydrological reservoirs. Although some of the hydrological processes can be modelled based on observations from various platforms (ground, balloon, aircraft, rocket, satellite), the model output needs ground-truthing and field validation for scaling it down to small watershed.

In the above context, application of stable and radioactive isotopes is an approach which can tag and trace the origin, movement and mixing of water through different phases of hydrological cycle. Various isotopes which can be used as markers or dating tools in hydrological studies include: ^{18}O, ^{17}O, ^{16}O, ^{3}H, ^{2}H, ^{1}H, ^{12}C, ^{13}C, ^{14}C, ^{3}He, ^{4}He, ^{81}Kr, ^{85}Kr, ^{36}Cl, ^{37}Cl, ^{39}Ar, ^{40}Ar, ^{222}Rn, ^{234}U, ^{238}U. Each of these isotopes, alone or in combination with other isotopes, can be used to address variety of hydrological problems and to obtain quantitative information about a hydrological process. Isotope application can provide information such as, for example: (1) age and flow direction of ground water, (2) horizontal and vertical flow velocity of groundwater, (3) average residence time of water in a surface reservoir, (4) source of vapour for rain, (5) movement of ocean water and mixing of fresh riverine influx, (6) groundwater - surface water interaction, (7) reconstructing temperature, relative humidity and rainfall in palaeo-hydrological set up. Among all, the oxygen and hydrogen isotopes, being integral part of the water molecules, are useful in tracing the movement of water along hydrological cycle and discerning the underlying processes. During phase change processes (evaporation, condensation, melting, sublimation, deposition) isotopes of oxygen and hydrogen are differentially partitioned between the two interacting phases in a manner predictable by the physics of isotope fractionation.

PRL is regarded as a center of excellence for isotope hydrology. PRL is leading a long-term National Programme on Isotope Fingerprinting of Waters of India (IWIN) which is aimed at isotopically characterizing various components of hydrological cycle over the Indian sub-continent to understand those hydrological processes which are not amenable to simple measurements of volumes and fluxes. A national facility for analyses of oxygen and hydrogen isotopic composition of water and vapour samples has been developed at PRL which pursues the isotope hydrology research in collaboration with universities, research institutes and central agencies.

The most significant output of IWIN programme is successful generation of large isotope dataset based on which isotope maps of precipitation and groundwaters of India are generated. These maps and dataset have provided new insights about complex hydrogeological and hydrometeorological processes, not known so far. The scientific output from IWIN programme is very important from the point of both basic research and societal application. The new data is being continuously added to IWIN dataset, maps are being updated and hydrological understanding is improvised.

Representative isotope maps of precipitation and groundwaters of India generated from IWIN programme, are given in the figure 1 and 2 respectively. These maps can be interpreted to derive region specific important hydrological information.

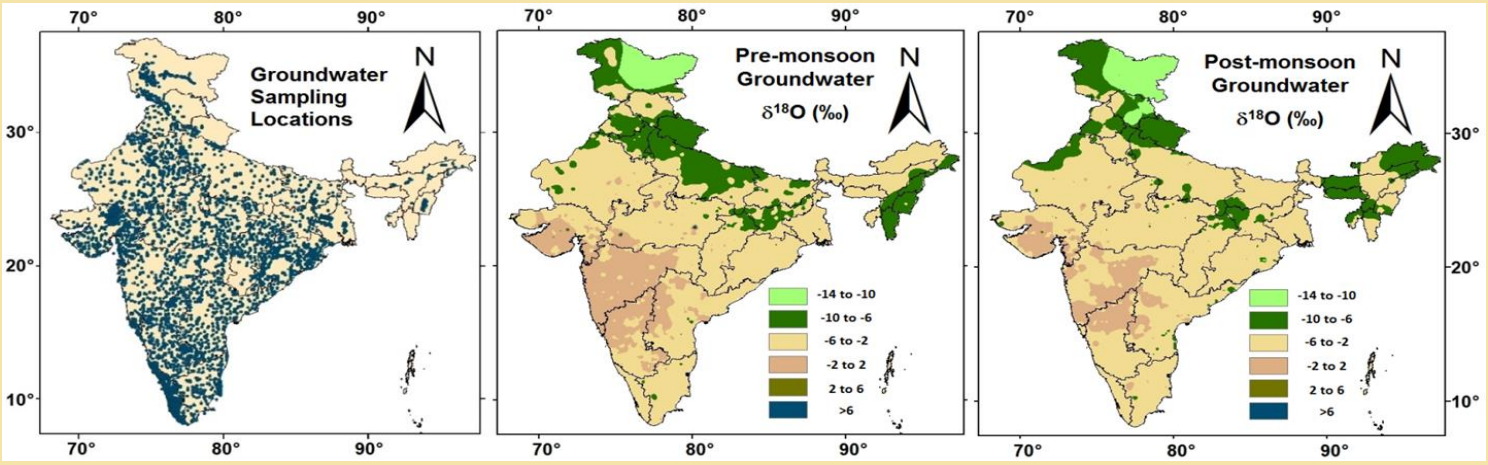


Figure 2. Map of pre-monsoon and post-monsoon oxygen isotopic composition of groundwater samples collected from 3000 locations across India. Seasonal and spatial variation in isotopic composition can be interpreted in terms of region specific geohydrological processes, and surface water – groundwater interaction.

Exploring dark matter, neutrino mass and $R_{K^{(*)},\phi}$ anomalies in $L_\mu - L_\tau$ model

(S. Singirala, S. Sahoo and R. Mohanta)

Suchismita Sahoo

We investigate Majorana dark matter in a new variant of $U(1)_{L_\mu - L_\tau}$gauge extension of Standard Model, where the scalar sector is enriched with an inert doublet and a $(\overline{3}, 1, 1/3)$ scalar leptoquark. We compute the WIMP-nucleon cross section in leptoquark portal and the relic density mediated by inert doublet components, leptoquark and the newZ'boson. We constrain the parameter space consistent with Planck limit on relic density, PICO-60 and LUX bounds on spin-dependent direct detection cross section. Furthermore, we constrain the new couplings from the present experimental data on $b \to sll, b \to s\gamma, \tau \to \mu\overline{\nu_\mu}\nu_\tau$ and $B_s - \overline{B_s}$ mixi-ng. Using the allowed parameter space, we estimate the$P'_{4,5}$observables and the lepton non-universality parametersR_K, R_{K^*}andR_ϕ. We observed that the parameter region satisfying only dark matter observables have a good impact on the flavor anomalies. We also briefly discuss neutrino mass generation at one-loop level and the viable parameter region to explain current neutrino oscillation data.

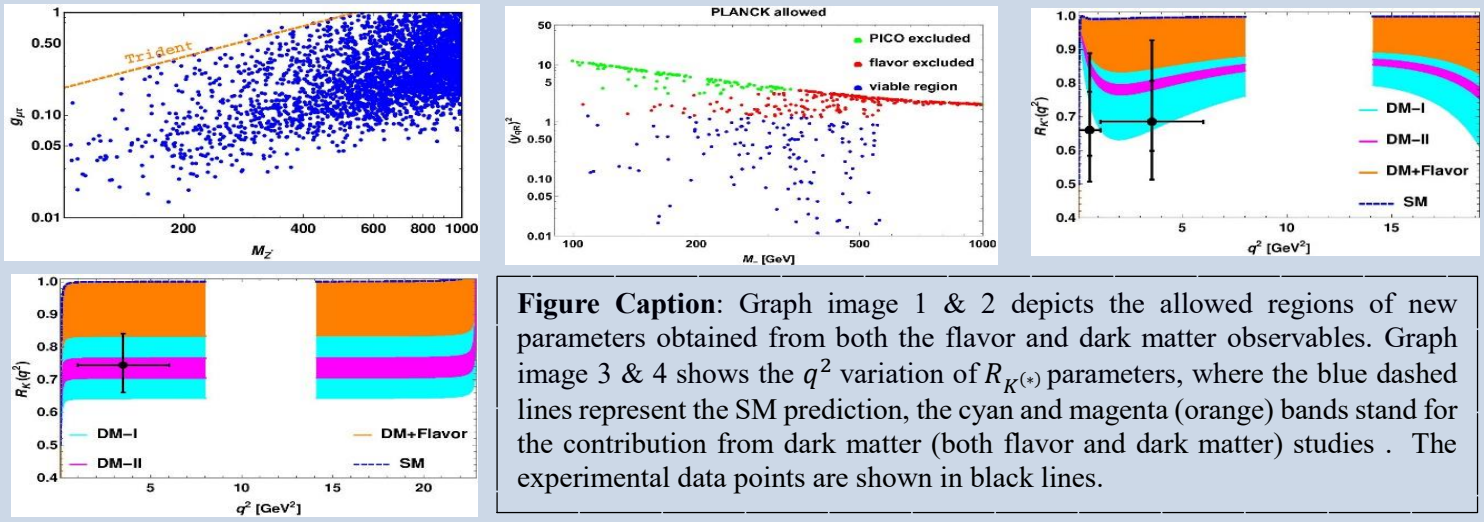


Figure Caption: Graph image 1 & 2 depicts the allowed regions of new parameters obtained from both the flavor and dark matter observables. Graph image 3 & 4 shows the q^2 variation of $R_{K^{(*)}}$ parameters, where the blue dashed lines represent the SM prediction, the cyan and magenta (orange) bands stand for the contribution from dark matter (both flavor and dark matter) studies . The experimental data points are shown in black lines.

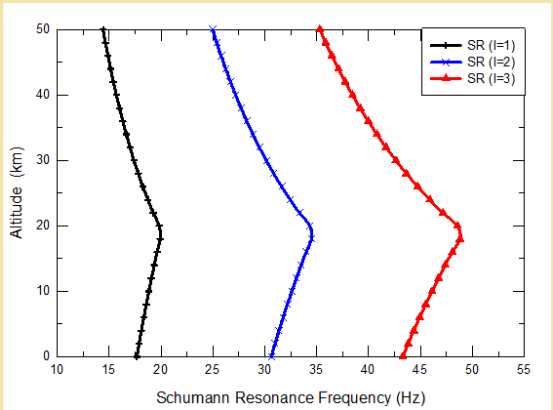
https://journals.aps.org/prd/abstract/10.1103/PhysRevD.99.035042

Schumann resonance frequency and conductivity in the nighttime ionosphere of Mars: A source for lightning

(S. A. Haider, J. P. Pabari, J. Masoom and S. Y. Shah)

Jayesh Pabari

We have solved the Maxwellian equations of electromagnetic waves, which oscillate within the cavity formed in the lower ionosphere of Mars between 0 and 70 km. The electrical conductivity and Schumann Resonance (SR) frequencies are calculated in the lower ionosphere of Mars, in the presence of a major dust storm that occurred in Martian Year (MY) 25 at low latitude region (25°–35°S). It is found that the atmospheric conductivity is reduced by one to two orders of magnitude in the presence of a dust storm. It represents a small dust layer at about 25-30 km altitudes, where the lightning can occur. We also found that the SR frequencies peak at ~18 km with values 19.9, 34.5 and 48.8 Hz for the modes $l = 1$, 2 and 3, respectively, in the non-homogeneous medium, as shown in Figure. Our results indicate that practical or measurable values of SR are dependent on the altitudes.



https://doi.org/10.1016/j.asr.2018.12.006

Figure Caption: Altitude profiles of Schumann Resonance frequencies in the nighttime ionosphere of Mars in MY 25, during high dust storm (τ = 1.7) at low latitude region (25-35°S).

Celebration of International Women's Day on 8th March 2019

The International Women's Day, 2019 was celebrated with great enthusiasm at PRL on 8th March, 2019. Interactive sessions were organized and the female employees of PRL acknowledged with mementos. Dr. Anil Bhardwaj, Director PRL had interactive session with all the female employees of PRL and asked them to share suggestions to improve the working conditions or to solve problems faced by them. Suggestions were made by few employees by expressing their concern regarding improvement of ladies washrooms and cleaning services across the campuses of PRL. The Director was very receptive to the suggestions and agreed to set up an on-line portal to register grievances. The Director also announced that a Women's Cell would be set up to oversee all female-centric issues at PRL. The Registrar too expressed his concern over the various problems faced by the women and responded positively to the queries. This interactive session with the Director was followed by a lunch.

Later in the afternoon, IWD celebration session open to entire PRL community was held with attendance of ~200 persons. The session started with a cultural programme that included a welcome song, followed by a fusion dance, Hindi poem recitation and mridhangam-jugalbandi by PRLites. The Registrar, Mr. CVRG Deekshitulu, in his welcome speech touched upon the 2019 UN Theme *#BalanceforBetter* and urged everyone to come forward to work towards betterment of women in the society. Ms. Ruzan Khambhatta, the invited speaker, impressed the audience with her informal way of interaction along with conveying some strong messages of remaining happy always as the key to success. She took special note of the large male colleagues who turned up at the event unlike other places and was extremely appreciative of their participation. She gave insight into the everyday difficulties and encouraged women to be in control of their thoughts and actions. To bring this change, she emphasized the need to have self-respect and give absolute involvement in their work. Her talk was interspersed with jokes and witticisms that kept the audience engaged.

The Director in his speech stressed upon the importance of giving equal opportunity without considering anything else, without any bias, to do it at the face value to ensure this year's UN IWD theme *#BalanceforBetter*. A brief report on the activities of the Internal Committee was read out and the programme ended with vote of thanks.

National Science Day – 2019 celebrated at PRL

National Science Day (NSD) in India is celebrated on 28th February each year to mark the discovery of the Raman Effect. The major focus of the NSD celebration is to widely spread the message about the importance of science in the daily life of people. As a result, this event is celebrated all over the country in schools, colleges, universities and other academic, scientific, technical, medical and research institutions.

PRL celebrated NSD on 2nd March, 2019 by conducting various competitive events among the students selected through a screening test conducted on 20th January, 2019. Five students were awarded the ArunaLal fellowship selected through personal interview. Unlike previous years, this year screening test in online mode along with the offline mode was initiated with the aim to facilitate the students to appear from their school without travelling to exam centres, sometimes situated at a far distance. In NSD-2019, a total of 1494 students appeared in the screening test on 20th January 2019 out of which 1298 and 196 students' opted offline and online exam, respectively. The highest marks scored is 100 out of 120. In total, 152 students were selected to participate in various events organized in PRL. Additionally, to popularize girl child education PRL invited 151 girl students from schools across Gujarat to visit PRL. Centre toppers of the 14 exam centres were also awarded prizes. In addition, 12 for poster/model competition were also given to the students who presented their models/posters on the topics i) Sequences and series in nature, ii) IOT-your idea of improving human life.

The year 2019, marks the birth centenary year of Dr.Vikram A. Sarabhai, the father of Indian Space Programme and of PRL. He encouraged young and brilliant students who desire to excel in innovation and serve the country in scientific endeavour. To commemorate the birth centenary year of Dr. Vikram A. Sarabhai, three new programs have been initiated by PRL to encourage young students towards science.

SCIENCE EXPRESS, in which scientists and researchers from PRL visit remote places of Gujarat and Rajasthan to demonstrate scientific activities of PRL through hands-on experiments. So far, more than 6000 students of rural background have been covered.

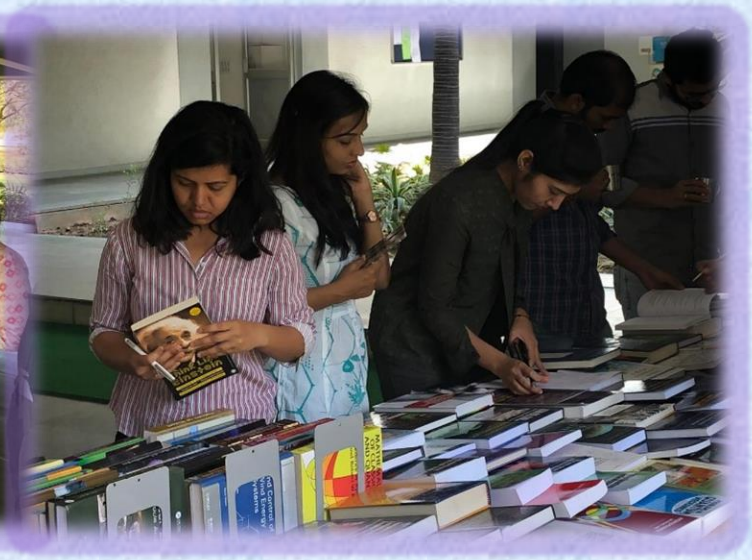
VISION 2019- VIkram Sarabhai InnovatiON competition has been announced. With this program PRL encourages B.Sc./Int. M.Sc./M.Sc. / B.Tech./B.E students for innovative ideas. Five such ideas will be selected and provided with Rs. 3 lakhs each to implement their idea. Finally, they will be required to demonstrate their idea with a prototype. There are three categories of prizes viz. 3 lakhs, 2 lakhs and 1 lakh for first, second and third projects, respectively.

VOICE-2019 Vikram Sarabhai Competition for Concept-Essay Writing 2019 for school students of class 8 to 12 standard, two age groups, e.g. 8-10 standard and 11-12 standard has been announced. The essay competition will be organized in two phases. First phase: thirty essays from each age group will be shortlisted. Second phase: All short-listed candidates will be invited to PRL for presentation and eight essays from each age group will be awarded cash prize and certificate. The topic for 8-10 age group is "Home at a distant planet" and 11-12 age group, "innovative experiments for space station".

PRL Delegation to the National Conference ATULYA 2019 at ISRO Propulsion Complex (IPRC), Mahendragiri

On the occasion of International Women's Day-2019, a three-member delegation comprising of Ms. Ishita Shah, Ms. Sneha Nair and Ms. Jaldhi Mehta was deputed by PRL to the National Conference ATULYA 2019 organised by IPRC, Mahendragiri, during 8th to 9th March 2019. They represented PRL at IPRC and attended the conference which gave them an insight into the role of women in the fields of Science and Technology. The conference marked its beginning with a keynote address by Chief Guest Anuradha Reddy, Member, Governing Council, INTACH, Hyderabad on the topic "Balancing Life". There were also talks by Invited Speakers Kinnara Moorthy, Former Dean, ASCI Management College, Hyderabad and Dr. Lalithambika, Director, Directorate of Human Space Programme, ISRO HQ. They delivered talks on "Professionalism at work place" and "Women in changing world of work", respectively. On the second day of conference, Dr. Renu Devaprasad, Anesthesiologist & Pallative care Physician, Jeyaseharan Hospital delivered an invited talk on "Women's health: Balance for better". Invited talks were followed by paper presentations. The conference included around 200 delegates from all ISRO centres. The delegates from PRL also took part in the cultural event of the conference

Book Exhibition at PRL Thaltej Campus



Library organized a book exhibition programme at Thaltej Campus on 19th March, 2019. In total, 329 titles on Astronomy and Astrophysics, Planetary Sciences, Geosciences, Atomic, Molecular and Optical Physics, Theoretical Physics, Space and Atmospheric Sciences and related topic were displayed by three book-sellers. The exhibition saw a very active and enthusiastic participation from staff and students both. They recommended a large number of books for library and book grant. Staff members and students very well received the event and they look forward to more such events in Thaltej Campus.

Scientific Tour to Jodhpur & Osiya (Rajasthan)

Staff Welfare Committee (SWC), Mount Abu conducted a Scientific Tour to Jodhpur and Osiyan during 16th – 17th March 2019. Members from Mt. Abu Observatory visited the Machia Biological Park, Jodhpur - an ideal place for nature and wildlife admirers; Blue bull, rabbit, desert fox, wildcat; deer, monitor lizard, monkey and mongoose were spotted there in their natural habitat. The Group also visited the Mehrangarh Fort and Museum- located at the right edge of Thar Desert and Umaid Bhawan Palace, Jaswant Thada, Mandore Garden in Jodhpur. Osiyan Mata Temple & Osiyan Jodhpur Sand Dunes in Osiyan were also visited.

Voluntary Blood Donation Camp

There is no great joy than saving a human life. Voluntary blood donation is one of the noblest activities. Dispensary PRL arranged voluntary blood donation camp at Navrangpura Dispensary on Friday, 15th March 2019. The camp was arranged in association with Department of Immunohematology and Blood Transfusion, B.J. Medical College & Civil Hospital, Ahmedabad. Significant contribution was achieved from our employees, Students, Trainees, CHSS beneficiaries and other workers. The blood collection team from Civil Hospital has collected 47 bottles of blood in just 6 hours. All credit goes to voluntary blood donors of PRL.

Young Physicists' Meet (YPM) 2019

Young Physicists' Meet (YPM) is an annual conference organized by the students in the Theoretical Physics Division in PRL. The main aim of this conference is to provide a platform to the young researchers to discuss about their recent research activities in PRL. The conference was conducted from 18th to 20th March, 2019. The number of participants in YPM 2019 was 67. This included participants from IIT Gandhinagar, Gujarat University, Institute of Plasma Research and distinct divisions of PRL. There were useful and healthy scientific discussions among the participants, various exciting new ideas were shared during the conference.

The inaugural talk was given by Dr. Ketan Patel. He introduced and discussed the concepts of High Scale Super symmetry in an elementary way. The broad topics covered in the conference were Astroparticle Physics, High Energy Phenomenology, Cosmology, Neutrino and Flavor Physics, Ultracold Quantum Gases, Quantum and Non-linear optics and Astrochemistry.

Visit by Prof. K. Kasturirangan at Udaipur Solar Observatory (USO)

Prof. K. Kasturirangan, former ISRO Chairman, visited USO on 11th March 2019. This was his first visit to the Observatory following the commissioning of the 50 cm Multi-Application Solar Telescope. Prof. Kasturirangan also visited the old dome on the island where the 15 cm SPAR telescope has been refurbished to provide full-disk and high resolution images of the Sun. He was also given a tour of the e-CALLISTO and GONG stations in the office premises of USO. Prof. Nandita Srivastava briefed Prof. Kasturirangan on the ongoing and future research projects at USO. Prof. Kasturirangan stated that his visit, albeit short, was an illuminating and exhilarating experience, wherein the research activities at the Observatory had really come to grip in the fundamental problems of Solar Physics. He also commented that the tour of the facility and the presentation was ample proof to the vibrancy of the scientific activities and the highly promising future of USO.

ISRO- Structured Training Programme (STP), 2019 at PRL

The 10th Structured Training Programme (STP) of the ISRO-STP Calendar for the year 2018-19 was successfully conducted at Physical Research Laboratory (PRL), Ahmedabad during 4th -8th February, 2019. The theme for this ISRO-STP was **"Recent Advances in Scientific Research in the Earth, Planetary and Space Sciences using Ground and Space based data: Global Perspectives"**. A total of 40 scientists and engineers from 17 different centres of DOS/ISRO participated in the ISRO-STP 2019. Further, new JRF's and UN-CSSTEAP students at PRL were also invited to attend lectures. In the inaugural address Dr. Anil Bhardwaj, Director PRL welcomed all the participants and highlighted the importance and themes of the ISRO-STP 2019. About 22 distinguished scientists from ISRO centers, other reputed institutions and universities of India were invited to deliver talks in different sessions covering various themes of the program. These talks were organized during 10 different sessions, chaired by the eminent scientists of PRL. Noteworthy events comprising of 1st PRL–IAPT Dr. Vikram Sarabhai Lecture by Dr. Anil Bhardwaj, Director, PRL and Special Colloquium by Dr. Shailesh Nayak, Director, NIAS were also organized along with ISRO-STP 2019 at PRL. The Project work was an important component of the ISRO-STP program. All participants, in a group of 6-7, very enthusiastically completed their project work on eight different topics mentored by the scientists of PRL as project mentors with different fields of expertise. On 8th February, the ISRO-STP 2019 concluded after evaluation session, feedback session, distribution of certificate and memento to all participants by the director PRL. The contributions of students (JRF/SRF), postdoctoral fellow and PRL staff members were important in the success of the ISRO-STP 2019. ISRO-STP 2019 organizing team comprising, Dr. Som Kumar Sharma (Chair), Dr. Lokesh Kumar Sahu, Dr. Neeraj Srivastava, Dr. Arvind Singh and Dr. Vishal Joshi worked coherently with the Chair, PPEG, Dr. R D Deshpande for a successful ISRO-STP, 2019 at PRL.

Outreach

Science Express Continues its Journey

To mark birth centenary of Dr. Vikram A. Sarabhai, National Science Day 2019 team at PRL has planned to organise science exhibition/demonstrations at different places of Gujarat in coordination with schools/community science centres. The motive is to reach out to the general public and students and share the excitements of science. First two chapters already covered four places viz. Dhrol, Jamnagar, Rajkot, Kapasan and Udaipur. In the third chapter 28 volunteers from PRL, primarily PhD students, visited Vidyadhish Vidyasankul, Bhavnagar and Gandhi Kanya High School, Una to demonstrate 20 odd experiments and interact scientifically with numerous students, kids and common people.

Science Express, so far in these demonstrations at six places received overwhelming response from the students, teachers and common people with an estimated footfall of more than 6000. To do so, around 30 volunteers travelled around 2000 KM for 45 hours and delivered 1230 working hours of volunteered contribution in such demonstration and talk.

Awards and Honors

- **S.A. Haider** got felicitated for the ISRO- Merit Award-2017 during the ISRO Award ceremony held on 13th March' 2019 at Bengaluru. He has been awarded for his outstanding contributions in the area of Martian aeronomy and interaction of solar radiation and solar wind with Mars and Comets.

- **Prabir Kumar Mitra**, SRF, Udaipur Solar Observatory, PRL has received the *Best Poster Award* in the category of "Sun and Solar System" for his contribution entitled "Evolution of solar magnetic fields and large-scale reconnection events in extremely complex solar active region NOAA 12673" in the 37th Annual meeting of ASI held at CHRIST, Bengaluru during 18-22 February 2019.

- **Harsh Raj**, SRF, Geosciences Division, PRL has received *Second prize for his oral presentation* entitled "Surface ocean radiocarbon variability records from Andaman coral" in CCIVA 2019 held at IIT Kharagpur, during 26 February – 02 March 2019.

- **Nisha Bharti**, SRF, Geosciences Division, PRL has received *Second prize for her oral presentation* entitled "Estimates of paleo deep-water ventilation ages for the Indian Ocean using foraminifera" in International Conference on Climate Change Impacts, Vulnerabilities, and Adaptation: Emphasis on India and Neighbourhood (CCIVA 2019) held at IIT Kharagpur, during 26 February – 02 March 2019.

- **Romi Nambiar**, Project Scientific Assistant, Geosciences Division, PRL has received *Third prize for her oral presentation* entitled "Paleo-redox condition in the Arabian sea during Last Glacial Maximum and deglacial period" in CCIVA 2019 held at IIT Kharagpur, during 26 February – 02 March 2019.

- **Kaustav Chakraborty**, SRF, Theoretical Physics, PRL has been awarded the prestigious *Raman-Charpak Fellowship 2018*, jointly funded by the Department of Science and Technology, India and the Service for Science and Technology (SST), France.

- **Rahul Kumar Kushwaha**, SRF, Atomic, Molecular and Optical Physics division is selected by the scientific review panel of the council for the Lindau Nobel Laureate meetings to participate in the 69th Lindau Nobel Laureate Meeting where he will present his research work on "Layered ices in the Solar System".

Hearty Congratulations to all the colleagues conferred with these awards and honours !

- **Debasis Sengupta** (Chairman, Centre for Atmospheric and oceanic Sciences, IISc. Bangalore) gave a colloquium entitled "Biweekly Monsoon Mode in the Bay of Bengal" on 27th March, 2019.
- **Anil Bhardwaj** (Director, PRL, Ahmedabad) gave a public lecture on "Indian Planetary Missions" at Udaipur on 25th March, 2019.
- **G.D. Reeves** (Research Scientist & Fellow, Los Alamos National Laboratory, USA) gave a colloquium on "Space Sciences at Los Alamos National Laboratory – A Personal Perspective" on 20th March, 2019

The Editorial Team


Bijaya Sahoo


Partha Konar


A.Shivam


Deekshya Sarkar


Prashant Jangid


Neeraj Srivastava


Pragya Pandey


Som Sharma


Vivek Mishra


Rohan Louis


Garima Arora


Kartik Patel


Veeresh Singh