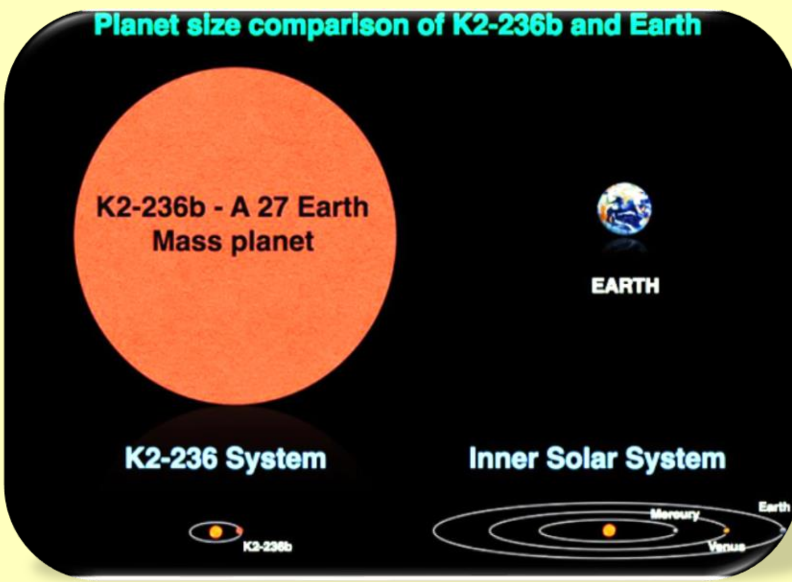
The Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP)
(Affiliated to the United Nations)

MEMOIRS

11th Space and Atmospheric Science Course
(August 1, 2018, to April 30, 2019)

Conducted by

Physical Research Laboratory, Ahmedabad, India



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Governing Members and Special Invitees during the 23rd G. B. Meeting on December 10, 2018, at New Delhi

The Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP)
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The image on the front cover: In an epic discovery, a team from Physical Research Laboratory has spotted a sub-Saturn exoplanet EPIC 211945201b (or K2-236b), which has a mass of about 27 Earth Mass, a size of 6 Earth Radii and an orbital period of 19.5 days, revolving around a Sun-like star EPIC 211945201 (or K2-236) about 600 light years away from us.

UNITED NATIONS
Office for Outer Space Affairs

15 April 2019

I wish to congratulate all students on the successful completion of the course and on obtaining the Post-Graduate diploma certificates. The United Nations Office for Outer Space Affairs (UNOOSA) values the efforts of the Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) as a capacity developer in the Asia Pacific Region and as a facilitator in 'bringing the benefits of space to humankind'.

Using space can unleash a range of benefits in virtually every aspect of the functioning of modern society, especially considering the challenges the world is facing due to climate change. Space-based technologies and space-derived information play a key role in climate knowledge, science, monitoring and early warning. Space-based information can contribute to assessing the vulnerability of communities to climate change and can help monitor the effectiveness of adaptation strategies. Moreover, space technology can help us mitigate and better manage natural disasters caused by climate change.

I am certain that this 9-month training programme has greatly increased the skills of its beneficiaries, who will now be able to use this knowledge to contribute to sustainable development efforts in their countries through space.

I extend my sincere thanks to the Director of the CSSTEAP and to the course coordinator and faculties for making this programme successful. I also want to thank the Chairman of the Indian Space Research Organisation for his precious support to the CSSTEAP.

Let me close this message by wishing the students success in their future achievements and expressing my confidence that they will greatly contribute to reaching new frontiers in leveraging space for sustainable development.

Yours sincerely,

Simonetta Di Pippo
Director
Office for Outer Space Affairs

Bringing the benefits of space to humanity

Office for Outer Space Affairs, United Nations Office at Vienna, Wagramerstrasse 5, 1400 Vienna, Austria
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ANDHRA UNIVERSITY

(NAAC - CGPA of 3.60 on four point scale at "A" grade)

"ISO 9001 - 2015 Certified"

Prof. (Col.) G . NAGESWARA RAO
M.Sc., Ph.D.,
VICE-CHANCELLOR

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13.04.2019

MESSAGE

I am happy that the 11th batch of PG Course in Space and Atmospheric Science will successfully conclude by 30th April, 2018. Being the focal point, Andhra University enjoys the association with this programme and it is a matter of delight and contentment. I congratulate the course participants, faculty, particularly Dr. J. Banerjee, Course Coordinator, Physical Research Laboratory, Ahmedabad on the successful course tenure of the 11th batch.

I wish all the very best to participants for their future endeavours.

(G. NAGESWARA RAO)

Centre for Space Science and Technology Education in Asia and the Pacific

(Affiliated to the United Nations)

Dr. K. Sivan
Chairman, CSSTEAP GB/
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MESSAGE

I am happy to note that the 11th PG Course on Space and Atmospheric Science, being conducted by Physical Research Laboratory (PRL), Ahmedabad from August 1, 2018 under the auspices of Center for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), is successfully concluding on April 30, 2019 with the participation of 13 students from 5 countries of the Asia-Pacific region.

The course was designed to enable the participants to get an in-depth understanding of the Space and Atmospheric science, with focus on Earth's atmosphere and ionosphere, Planetary science and exploration, Ground-based experiments, Space instrumentation and exploration, Electronic devices and detectors for space instrumentation, Sun and Space Weather, Stellar and Galactic Astronomy.

This course will encourage the participants to purse their career/research in areas like exploration of outer space, deep space and the Earth's environment. It will also help them to apply the space and atmospheric models in satellite communication and navigation, weather forecast, disaster monitoring and early warning systems, that play vital role in country's economy and social lives of the fellow citizens.

I am sure that the expertise gained and pilot projects implemented would help them to initiate major research projects and help their country in many ways. The contributions of the faculty and staff of PRL and CSSTEAP for the successful organization of this course is highly appreciable.

I wish the participants the very best in their future endevours.

(कै. शिवन / K. Sivan)

Dated: April 04th, 2019

डी के दास / D K Das
निदेशक / Director

सत्यमेव जयते

भारत सरकार GOVERNMENT OF INDIA
अंतरिक्ष विभाग DEPARTMENT OF SPACE
अंतरिक्ष उपयोग केंद्र
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ई-

MESSAGE

It gives me immense pleasure to know that ***11th PG Course on Space and Atmospheric Science,*** being conducted by Physical Research Laboratory (PRL), Ahmedabad under the umbrella of Center for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) has been successfully completed. It is of interest to note that a diaspora of 13 students from 5 countries of the Asia Pacific region have participated in this Programme.

I would like to congratulate all the participants for successfully completing the Course and I am confident that the enhanced working knowledge from this programme will reap benefits in their future assignments and will greatly contribute towards the development of space technology and its use towards societal benefits, which is the vision of Dr. Vikram Sarabhai.

I heartily extend my compliments to the faculties and the supporting staff who sincerely ensured the successful completion of the Programme.

Place: Ahmedabad
Date: April 4, 2019

(डी के दास)
(D K Das)

Centre for Space Science and Technology Education in Asia and the Pacific

Dr. A. Senthil Kumar

Director, CSSTEAP

Introduction

Geospatial information technologies have contributed significantly to the socio-economic development planning in most developed and developing countries. The Sustainable Development Goals (SDGs) that comprise the 2030 Agenda for Sustainable Development combined with the targets of the Sendai Framework for Disaster Risk Reduction and the commitments of the Paris Agreement for Climate Change contribute collectively to the overall global development goals, which are expected to be realized on national, regional and global scales. Space-based data and geospatial information are essential for implementation, monitoring and realization of these goals.

Focusing attention on Asia and the Pacific (AP) region of the globe, this region has become a hub of innovation which is transforming the way in which people live, work, and relate to one another. Recent advancement in digital innovation such as artificial intelligence, big data analytics, the internet of things and cloud computing show promise to bring new and innovative solutions to pressing regional problems. Faster and more versatile digital connectivity, satellite-derived data, geographic information systems and spatial analysis have become increasingly accessible and available, generating more evidence-based data to support real-time decision-making. Geospatial information has also increasingly been incorporated in development planning, which has led to more accurate monitoring and evaluation of development interventions. As a result, geospatial information applications have come to play a more prominent role in the implementation and realization of the 2030 Sustainable Development Agenda (SDGs).

Despite advances in the availability and quality of space-derived information, several gaps and challenges remain for their effective use at the AP regional and national level. A lack of capacity and resources in terms of finance, space-derived data, knowledge and expertise, specific tools and well trained human resources is a common problem. Many developing countries in the AP region still do not have the capacity to utilize, analyze and interpret space-derived data. Other challenges include issues related to policies, procedures, guidelines and standards for acquiring, sharing and utilizing space-derived products and services and the lack of procedural harmony between agencies and countries. A comprehensive training and education in Remote Sensing & Geographic Information System (RS & GIS) would enable developing countries to build a capability in the field and to educate and stimulate participants in other disciplines as well.

Considering the importance and use of space science, technology and applications in promoting social and economic development, the United Nations, through its Office for Outer Space Affairs (UN-OOSA), facilitated the establishment and operation of the Regional Centres for Space Science and Technology Education. In its resolution 45/72 of 11 December 1990, the United Nations General Assembly (UN-GA) endorsed the recommendation of the Committee on the Peaceful Uses of Outer Space (COPUOS) to establish Regional Centres for Space Science and Technology in developing countries. Under the auspices of the United Nations, through its Office for Outer Space Affairs (UN-OOSA), six Regional Centres for Space Science and Technology Education have been established in the regions that correspond to the United Nations Economic Commissions for Asia and the Pacific (India and China), Africa (Morocco, Nigeria) and Latin America and the Caribbean (with offices in Brazil and Mexico) and Jordan for the West Asia region. The Centres are affiliated to the United Nations through UN-OOSA. Centre for Space Science & Technology Education in Asia and the Pacific (CSSTEAP) is the first Centre and was established on November 1, 1995 in India and has been Centre for Space Science and Technology Education in Asia and the Pacific imparting education/training in the areas of RS & GIS, Satellite Communications, Satellite Meteorology and Global Climate, Space and Atmospheric Science, Navigation and Satellite Positioning System and Small Satellite Missions using modern infrastructure, technology and training tools and practices. The Centre has announced a new Post Graduate course on Global Navigation Satellite Systems (GNSS) from 2015 and is hosted by Space Applications Centre, ISRO Ahmedabad.

The Centre's headquarter is located in Dehradun, India, and its programs are executed by faculty of the Department of Space (DOS) at campuses in Dehradun, Ahmedabad and Bengaluru. The Centre has arrangements with Indian Institute of Remote Sensing (IIRS), Dehradun for RS & GIS course; with Space Applications Centre (SAC), Ahmedabad for Satellite Communication (SATCOM), Satellite Meteorology and Global Climate (SATMET) and Global Navigation Satellite System (GNSS) and Navigation and Satellite Positioning Systems (NAVSAT) short courses; with Physical Research Laboratory (PRL), Ahmedabad for Space & Atmospheric Science course and UR Rao Satellite Centre (URSC), Bengaluru for short course on Small Satellite Missions. The Centre also has an agreement with the Government of India by which it has been accorded specific privileges and international status to the Centre, similar to the privileges enjoyed by UN specialized agencies. Under the agreement, the Centre also has access to facilities, infrastructure and expertise of DOS/ISRO institutions, including IIRS, SAC, PRL, NRSC and URSC. The Centre has a Governing Board consisting of signatories from **17** countries from Asia-Pacific region and two observers, (UN-OOSA & ITC, The Netherlands). The Centre has formal UN affiliation with UN-OOSA for developing the CSSTEAP model and extending support in terms of expert advice, technical assistance, relevant documentation and future directions. The countries have agreed to the goals and objectives of the Centre by endorsing a cooperation agreement through which the Centre was established. The technical activities of the Centre are guided by an International Advisory Committee (AC) consisting of subject experts that critically reviews the curricula, technical facilities, expertise in terms of faculty, etc.

The course curricula developed by the Centre and endorsed by the United Nations are adapted for the educational programs. The educational programs of the Centre are oriented towards the dissemination of knowledge in relevant aspects of space science and technology. The Centre offers Post Graduate level courses in these five areas. The model of the PG courses is designed as to emphasize university educators, researchers and application scientists on the development and enhancement of knowledge and skills coupled with an application project with a small component (3 months) in India and major one (one year) in their home country with a view to transfer the technology in their home organization. This gives an opportunity to the scholar to apply their knowledge and training received to deal with a 'real life' problem, where inputs from space technology can be used. Besides the Post Graduate level courses, the Centre also conducts short courses, workshops, awareness programs on specific themes in the four areas, highlighting how space-based information can be used for national development. These educational programs have benefited many scientists/engineers who will be the future policy & decision makers in several countries.

CSSTEAP conducts all of its educational programs in close collaboration with one of the DOS institutions and thus has direct access to their physical facilities and intellectual capabilities. In addition to providing facilities, infrastructure and skilled manpower, the Government of India, through the Department of Space provides most of the funding. Funding grants for international travel of participants, subject experts, tuition fees and scholarships of participants and the management of the Centre are mainly provided by the Department of Space on behalf of the Host country. UN-OOSA also provides funding for travel of the participants. Other agencies financially contribute include are UN Agencies like UN-SPIDER, Beijing, China; UN-ESCAP in Bangkok, Thailand, UNESCO and UNDP.

Educational Programs

The Centre offers post-graduate (PG) level training in five areas of specialization namely:

a) Remote Sensing and Geographic Information Systems (RS & GIS),
b) Satellite Communication (SATCOM),
c) Satellite Meteorology and Global Climate (SATMET)
d) Space and Atmospheric Science (SAS), and
e) Global Navigation Satellite Systems (GNSS).

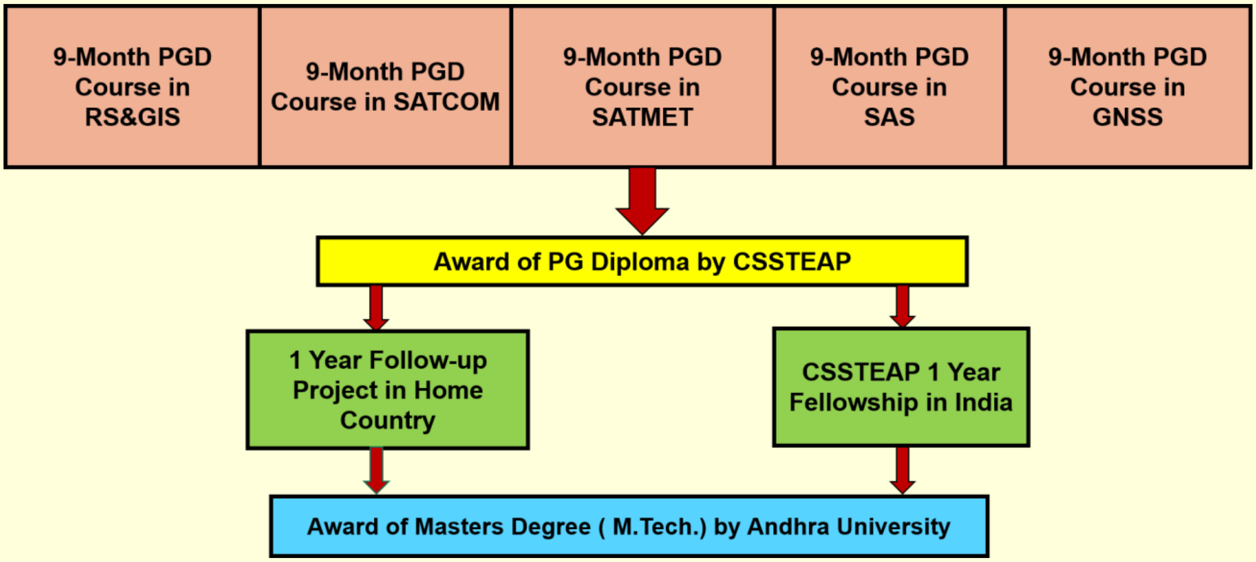


Fig. 1: Structure of PG Diploma Educational Programs at CSSTEAP

Apart from these, Centre conducts short courses on different themes of Remote Sensing and GIS, Small Satellite Missions and Navigation and Satellite Positioning system on a regular basis. The structure of the PG Diploma and the short term programs is given in (Fig. 1 & 2). The Centre also organizes workshops & awareness programs from time to time.

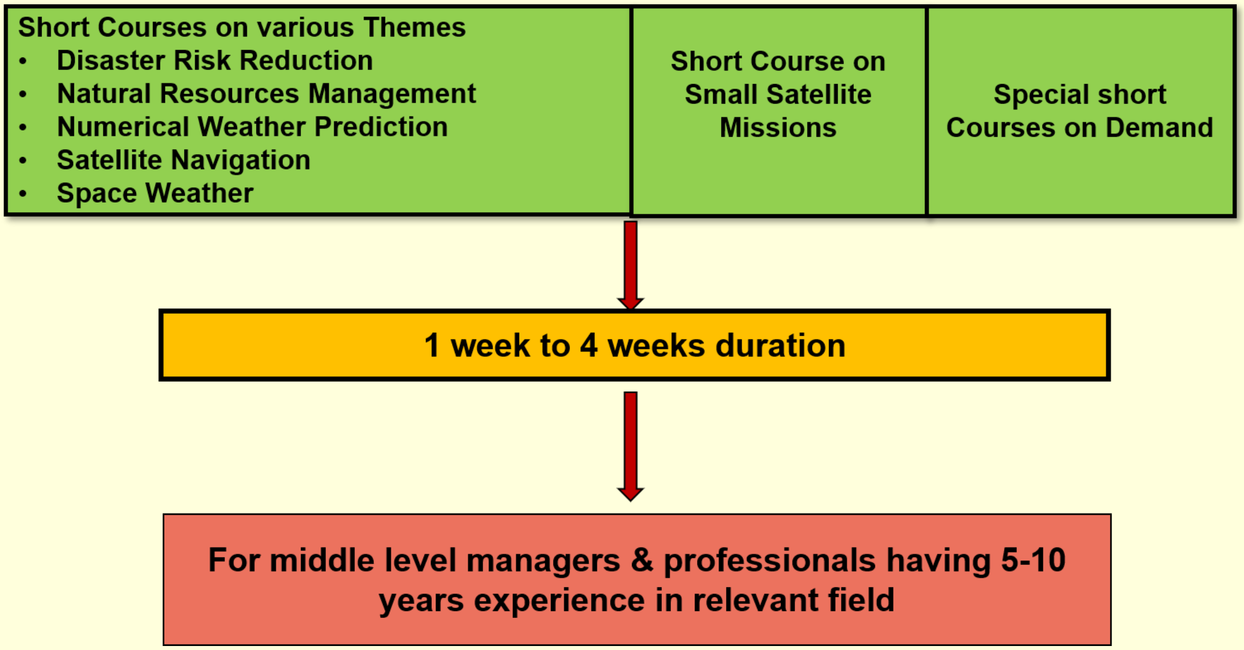


Fig. 2 Short term training programs at CSSTEAP

The educational programs are conducted in English and for participants who need help to improve their English language skills, facilities are made available upon their arrival on the campus. The courses are taught in smart classroom environments with the use of modern teaching methods and tools, and also include multimedia tutorials for self-study. Practical are given in the laboratories and skill development environments of the DOS institutions. In each of the host institutions, most of the faculty is drawn from the host institutions (about 80% of the teaching time). Whenever desirable or needed, faculty are drawn from other DOS/ISRO institutions, or professional, scientific or academic institutions in India (~10%) or from institutions or organizations outside India, from the Asia-Pacific Region as well as globally (~ 5%). In order to provide wider exposure to the participants in their respective fields, the Centre provides opportunities for technical visits to scientific institutions, laboratories and national symposia in India. The successful completion of the 9-month PG-Phase of the programme leads to the award of a Post Graduate diploma by the Centre. For the participants who successfully finish their PG course and are interested in continuing for a Master of Technology (M.Tech.) degree, the Centre offers the opportunity to do so, in collaboration with Andhra University (AU) in Visakhapatnam, India. To this end, the student has to complete a 1-year research project in an application of space science or technology. This project has to be approved by CSSTEAP and AU, and the research is supervised by designated academic staff of CSSTEAP, AU and the institution where the research is carried out. In most cases, the 1-year project is carried out at the home institution of the student concerned. Since 2004 onwards every year selected meritorious PG participants in RS & GIS are being given fellowships to complete their M.Tech. thesis work at CSSTEAP.

Till date, 158 PG participants (76 in RS & GIS; 41 in SATCOM; 20 in SATMET and 21 in SAS) from 16 different countries have been awarded M.Tech. degree. (Fig. 3)

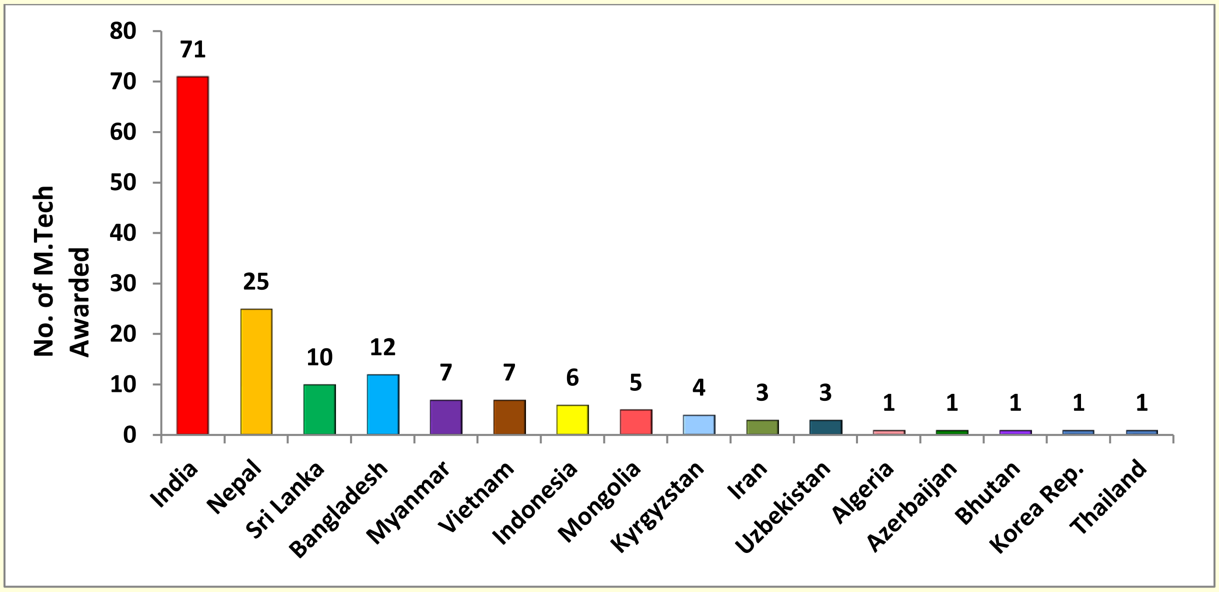


Fig. 3: Status of M.Tech degree awarded

Space and Atmospherics Science course

Today, space and atmospheric sciences are being used for not only exploring the earth's environment and outer space but also in a variety of societal applications. Especially, applications in satellite communications, accurate weather forecasts through meteorological satellites, TV broadcasts and educational outreach programs, earth remote sensing, satellite navigation, satellite geodesy and satellite-based disaster warning systems play a crucial role in our day-to-day life. Space platforms such as balloons, rockets and satellites or deep space probes are being used to probe the oceans, earth's near environment, upper atmosphere, ionosphere, magnetosphere, solar system and beyond.

The 9 month Post Graduate (PG) course in Space and Atmospheric Science (SAS) at Physical Research Laboratory (PRL) is aimed to enhance the concepts and applications of SAS for the scientists, professionals of the Asia-Pacific region working in the field of Physics, atmospheric sciences, engineering in electronics and allied fields. The PG course of 9-month duration is divided into two semesters including the pilot project in the second semester. The 1st semester covers specific areas of Space science including Earth's Atmosphere and Climate Change, Ionosphere and Radio Communication, Planetary Science and Exploration, Near-earth Environment Ground-Based Experiments for Space Instrumentation etc. and the 2nd semester covers the topics on Sun and Space Weather, Stellar and Galactic Astronomy, Electronic Devices and Detectors for Space Instrumentation and Space Exploration.

The pilot project module is designed such that the participants develop a reasonable depth of understanding of the field under the guidance of a supervisor from the host institute. The PRL has very active doctoral and post-doctoral programs.

PRL is known as ‘cradle’ of India Space Programme. Over the years, the PRL has developed very sophisticated ground-based as well as space–borne experiments. Recently, scientists at Physical Research Laboratory (PRL), Ahmedabad, discovered a new planet around a Sun-like star at 600 light years away from the earth. This discovery led India to join a handful of countries capable of discovering exoplanets.

Achievements

Till date the Centre has conducted 58 PG Courses: 23 in RS&GIS, 11 in SATCOM, 11 each SATMET and SAS and 02 in Global Navigation Satellite System. Currently 11th SATMET course at SAC, Ahmedabad and 11th SAS course at PRL, Ahmedabad are in progress. In addition, the Centre has conducted 54 short courses and workshops in the past 23 years. These programs have benefited some 2090 participants from a total of 36 countries in the Asia-Pacific region and 29 participants from 19 countries outside the Asia Pacific region have also benefited from these educational programs.

The Centre has played a major role in the development of curricula of four courses which are currently being followed by all the UN-Regional Centres. All course materials are published by the Centre in the form of hard-copy lecture volumes and CDs. The Centre further publishes conference proceedings and other outreach documents, such as general information brochures, course announcement brochures, newsletters and memoirs- marking the end of every PG course. A half-yearly newsletter is published regularly and sent to all alumni and to persons and institutions associated with the Centre. CSSTEAP has scientific and research collaborations with the University of Illinois, USA; TWAS-UNESCO; ICIMOD, Nepal for cooperation and mutual assistance in the areas of education and research.

In order to obtain first-hand feedback, understand the alumni role in promoting space technology in their countries and to develop a network & establish meaningful linkages between CSSTEAP & its alumni, CSSTEAP has taken initiative to hold alumni meets in different countries of the region. In this direction, five alumni meets have been successfully conducted: in Kathmandu (Nepal); Dhaka (Bangladesh); Colombo (Sri Lanka); Thimpu (Bhutan) and Yangon (Myanmar).

Pilot research case studies in the form of student project work showing the potential application of space science and technology in natural resources management, improved meteorological, communications studies etc., in Asia-Pacific region is being done by the Centre. The Centre initiated research activities in the form of Phase-II of PG course i.e., M.Tech research work by eligible PG participants. The Centre has taken initiative to facilitate its alumni to do higher studies leading to Ph. D. degree and M. Sc. and Centre provides support in terms of expert faculty to guide the student for analyses and logistics (accommodation, research lab, library access, etc.). During the 2018-19, a total of six participants have been supported with CSSTEAP M.Tech fellowship namely three participants from India, two from Bangladesh and one from Sri Lanka. To generate awareness among users, researchers, engineers, professionals, decision-makers and academicians, in the year 2018, the Centre organized 2 short courses on specialized areas of Remote Sensing & its applications:

1) Geospatial Modelling in Forestry and Ecology for Climate Change Response Studies from April 16 to April 27, 2018)
2) Disaster Risk Reduction (DRR) with Special Emphasis on Floods and Earthquakes from May 28 to June 22, 2018

The Centre has established international linkages with various organizations viz., UN-OOSA, UN-SPIDER, SAARC, UN-ESCAP, UNESCO, UNDP, COSTED, WMO, START-SASCOM, NAM S & T, TWAS towards few fellowships/travel support/ sponsor short courses. There are also linkages with other Universities / Institutes (Institute of Space and Astronautical Science (ISAS), Japan; University of Illinois; Freiburg University, Germany; SSNEOG, Australia; EUMETSAT, U.K, Onera, France; University of Colorado, University of Reading, U.K; NOAA-USA, University of Wisconsin, USA; University College of London, U.K; University of Hannover, Germany, etc.) for Guest Faculty and scientific exchange programs. In India, apart from DOS/ISRO Centers CSSTEAP has linkages with many universities and academic institutions for imparting education/training.

As mentioned in the introduction about the 2030 Agenda for Sustainable Development that includes 17 Sustainable Development Goals (SDGs). Building on the principle of "leaving no one behind", the new Agenda emphasizes a holistic approach to achieving sustainable development for all. CSSTEAP is also committed to achieve the SDGs and has plans to include SDGs in CSSTEAP core courses. In the year 2018, CSSTEAP have arranged Lectures on

1) "Overview of Sustainable Development Goals (SDGs)" by Dr. Shirish Ravan, UNOOSA through Skype on October 8, 2018.
2) "Building Space Application Capacity for Disaster Risk Reduction" by Dr. Sanjay Srivastav, UNESCAP through Skype on June 14, 2018.

In addition, during 2019 CSSTEAP is also planning to conduct Global Webinar series (CEOS/GEO/UN) with RCs on SDGs.

CSSTEAP has also introduced Space Law concepts and arranged a guest lecture on

1) "Space Law: International Treaties & Regulations" by Mr. Gopala Krishnan, ISRO HQ. on October 27, 2018.

CSSTEAP has supported SAARC with Resource Person on EO data for rapid response & open source data portals for DM for SFDRR during 2018 on a workshop on Utilization of Space-based & Geospatial information for achieving the targets of the Sendai Framework for DRR".

Besides above, CSSTEAP has supported offshore training programs jointly organized by UNOOSA/UN-Habitat one at China and Two at Myanmar on Disaster Risk Reduction and Damage Assessment.

The Centre plans to encourage research programme to the interested scholars. The Centre has been serving tirelessly towards the capacity building in the Asia-Pacific region and has significant achievements since its inception. I am sure, given the rapid pace of space technology advancements, there are challenging tasks ahead for us to accomplish in the future.

Physical Research Laboratory

Host Institute for Space and Atmospheric Science Course

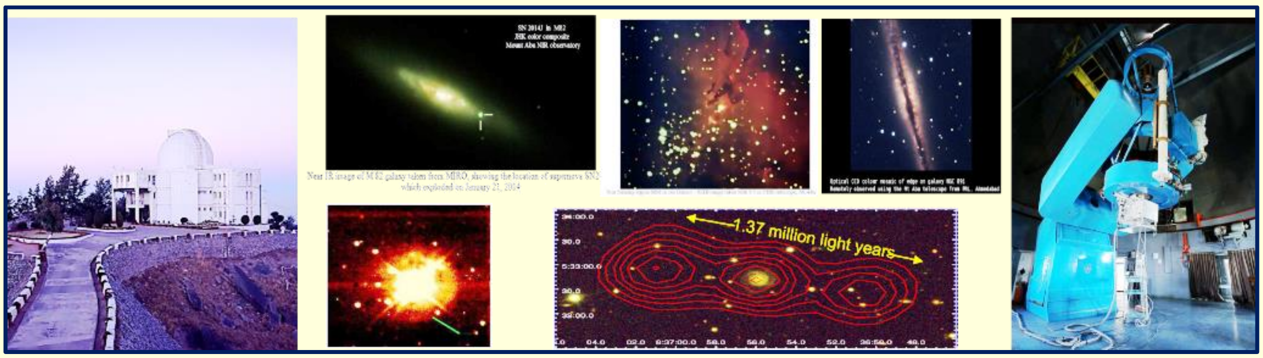
Dr. Anil Bhardwaj, Director

PRL Main Campus

Physical Research Laboratory (PRL), founded in 1947 by Dr. Vikram A. Sarabhai, is a premier scientific institution under the Department of Space, Government of India. The laboratory started with its focus on research areas of Astronomy and Cosmic Rays. In the course of time, several new disciplines were added to its research theme. The current research activities of PRL are truly of multi-disciplinary nature at the cutting edge of science. These include Astronomy and Astrophysics, Space and Atmospheric Sciences, Solar Physics, Geosciences, Planetary Science, Atomic, Molecular & Optical Physics, Theoretical Physics & Cosmology. PRL currently has four campuses: the main campus at Navrangpura, Ahmedabad, with several world-class experimental and computing facilities; many leading laboratories in Thaltej campus, Ahmedabad; Optical and Infrared Observatory at Mount Abu, and Udaipur Solar Observatory at Udaipur. The research work done at PRL has been recognized by peers at both national and international levels. This is also reflected in International and national awards and honours received by PRL scientists over the years. The laboratory has a very strong human resource development component with doctoral (PhD), postdoctoral & visiting scientist programmes, summer internship programme for B.Sc./M.Sc. students and college teachers, project training for graduate and postgraduate students in science, engineering and computer applications. PRL also conducts biennial PG Course in Space & Atmospheric Science since 1998 for the Center for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) established in Dehradun which is affiliated to the United Nations.

Science at PRL

Astronomy and Astrophysics

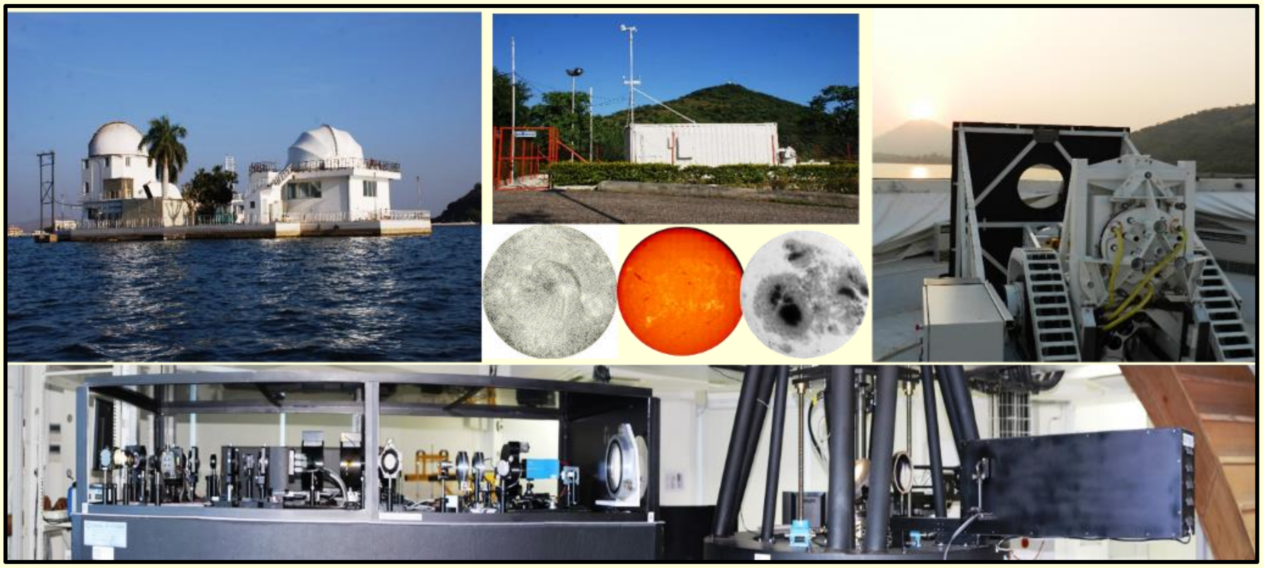


The sight of a dark night with millions of twinkling stars is fascinating and intriguing to human beings since time immemorial. Stars form in large molecular clouds that exist in space. With time, stars evolve and when their fuel, mainly hydrogen, is exhausted they become cooler, redder and bloat up in size, reaching a stage called super-giant. Some of them throw away their outer shell, forming spectacular planetary nebulae while others end their lives with a violent explosion, shining brilliantly, called supernovae. Remnants of stars turn into white dwarfs, neutron stars and black holes and vanish from sight but make their mysterious presence felt through strong gravity.

Electromagnetic radiation, from gamma-ray to radio, plays the role of a messenger telling us about these astronomical sources and events happening in the universe. Scientists at PRL are engaged in seeking answers to a host of questions on many exotic astronomical sources and events by analyzing radiation emanated by them. It requires light collecting telescopes, sophisticated instruments and basic techniques to decode messages coming from sources millions and billions of light years away.

The 1.2 mt. optical and IR telescope at Gurushikhar, Mt. Abu is one of the major facilities used by the PRL astronomers. The main scientific programmes pursued are as follows: hunt for extra-solar planetary systems, studies of various astronomical objects like the comets, star-forming regions, star clusters, novae, supernovae, variable stars, cool stars, X-ray binaries, pulsars, active galactic nuclei and gamma-ray bursts (GRBs). The scientists have been using multiwavelength observational data covering X-rays, to ultraviolet, optical, infrared, and radio wavelengths to carry out forefront research studies of astronomical objects. These data are obtained using various techniques, like photometry, spectroscopy, polarimetry, etc. with the help of several existing ground - and space-based national and international telescope facilities. They also utilize High-Performance Computing facility of PRL to explain various observational signatures. The observation capabilities at Mt. Abu are going to be enhanced with the 2.5 Mtr. telescope and its back-end instrumentation.

Solar Physics

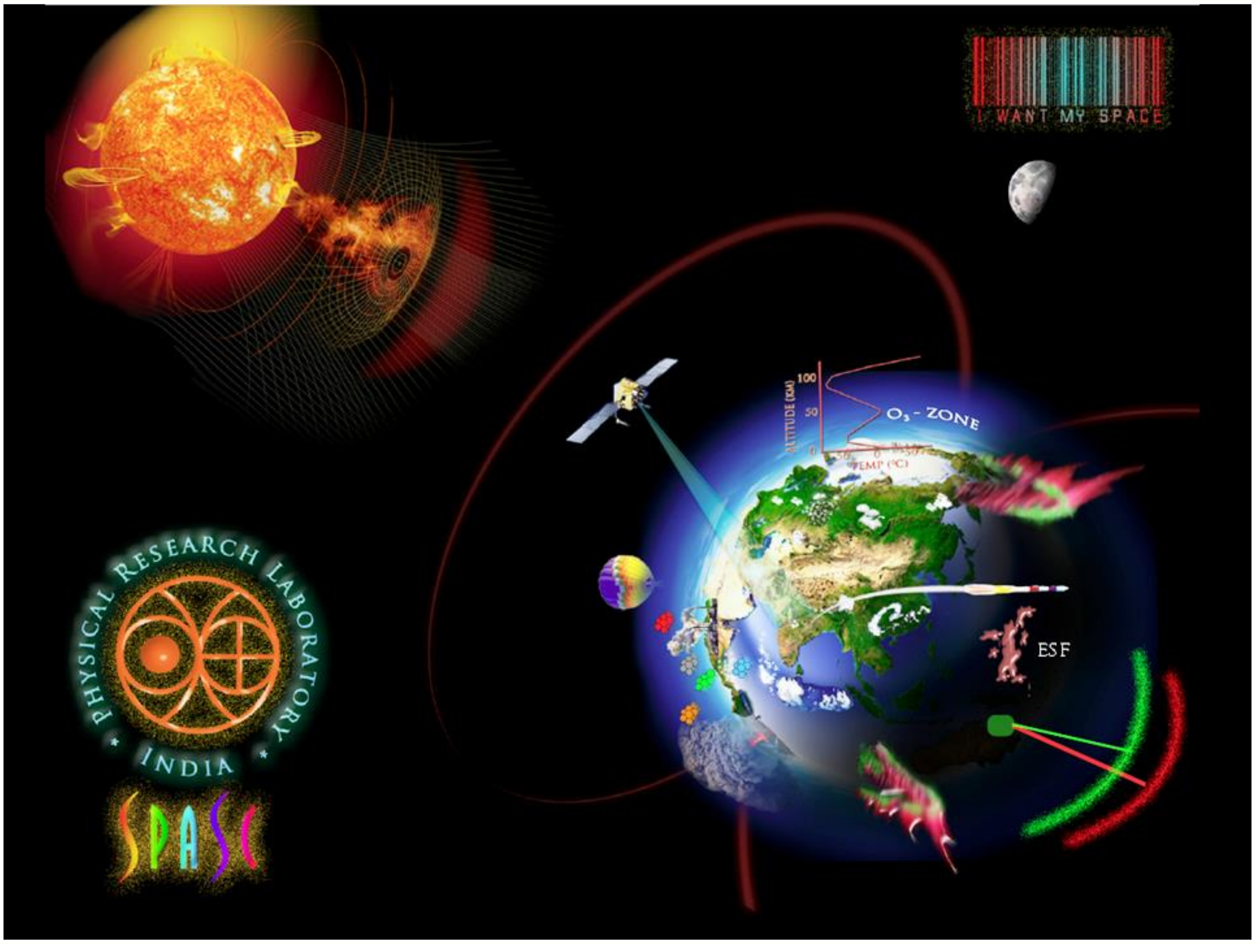


The Sun is our nearest star and an interesting cosmic object that helps in understanding stars and the astronomical universe. The close proximity of the Sun reveals fine details of its outer visible surface at widely ranging spatial and temporal scales; not possible to achieve for other distant stars. It is a giant physical laboratory in which energy is generated by nuclear fusion; controlled reproduction of which is still not achieved on the Earth.

As the Sun heats the ground, thermal air turbulence develops in the surrounding atmosphere, blurring the visibility of fine features on the solar surface. Therefore, a good solar observing site should be located in a suitable place to reduce this effect. With this objective, a unique solar observatory was established on a small island in the middle of Lake Fatehsagar, Udaipur, in September 1975. The large body of water surrounding the observing site improves the 'seeing', and being in Rajasthan has the additional advantage of a large number of cloudless days needed for continuous observation of the Sun. Investigations of the Sun at Udaipur Solar Observatory (USO) revolve around the central theme of solar magnetic and velocity fields, solar activity, solar eruptive processes and high-resolution solar observations. Basic physical phenomena of the birth and development of active regions and flare mechanism are also being studied. The data obtained at USO are available to scientists working on related fields, and various national and international organizations. The scientists take part in several international collaborative programmes. In October 1995, USO joined the international project, GONG - Global Oscillation Network Group, to study several fundamental problems of the solar interior. One of its kind, Multi-Application Solar

Telescope (MAST), of 50 cm aperture with sophisticated back-end instruments was commissioned in 2015 for measurement of solar magnetic fields and imaging the solar surface and its atmosphere. The groups along with colleagues of various scientific institutes of India are now working on the first dedicated space-based solar mission, ADITYA-L1, for the study of the Sun from Lagrangian-L1 point. A new solar radio observing facility (e-CALLISTO) is also now commissioned.

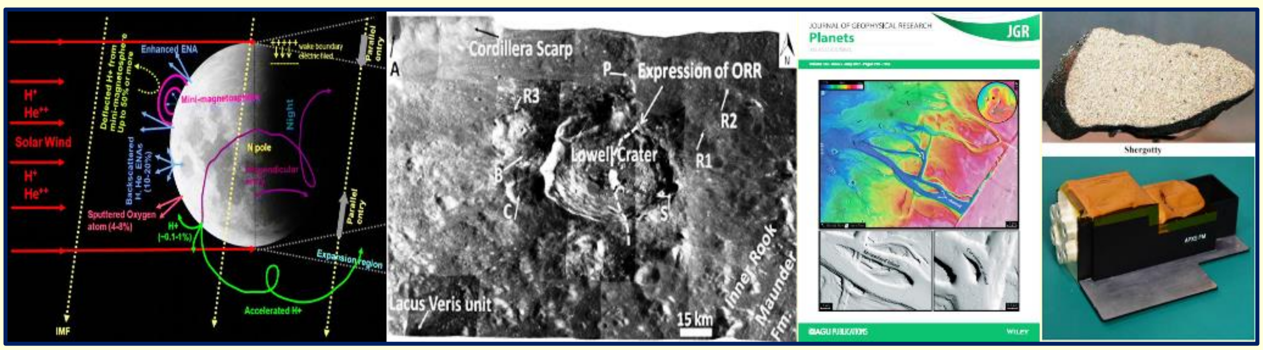
Space and Atmospheric Sciences



The presence of air and water on the Earth makes it a unique planet in our Solar System. These two reservoirs have played a major role in the evolution and sustenance of life on the Earth. Both the atmosphere and the oceans are in a state of perpetual motion and their composition is in a state of continuous change due to natural and anthropogenic causes. The scientists working in the Space and Atmospheric Sciences are engaged in studies to obtain an in-depth understanding of processes and feedbacks that have relevance to complex phenomena occurring in the atmosphere and to global change. Atmospheric research has been one of the major scientific activities of PRL since its inception in 1947. During these past decades, these studies progressed leaps and bounds mainly due to initiation of new and contemporary research programmes of global impact accompanied with new technological advancements, and contribution of the scientists in major leadership roles in both national and international fora.

The broad questions currently being pursued include: How do the concentrations of key atmospheric constituents such as trace gases, ozone, clouds and aerosols change with time and space, especially over and around the Indian sub-continent? What are their effects on the energy budget of the atmosphere? How does the space environment influence the earth-atmosphere system? How are the atmospheric regions coupled vertically and horizontally (across latitudes)? These questions are addressed through a multi-pronged approach, by conducting in situ studies using rocket and balloon-borne instruments, remote sensing at optical and radio wavelengths, as well as by analytical modelling. PRL scientists are leading the effort on the ISRO's Aeronomy satellite mission by contributing several payloads and payloads for satellite investigations of solar wind interactions with Venusian and Martian ionospheres. Further while continuing its effort in probing the atmosphere and the space environment around planets and other solar system objects the group has plans to make space-based observations of trace gases and atmospheric parameters.

Planetary Sciences



The study of the atmospheres, surfaces and interiors of solar system objects, and the processes that govern them constitutes planetary science research at PRL. This is achieved through theoretical models (computer simulations), laboratory studies of meteorites and samples from planetary bodies, remote sensing analysis, and spacecraft-based observations through planetary missions. Initiated with Chandrayaan-1, and the associated landmark discovery of water on the Moon, design and development of instruments for planetary missions (payloads) has now become one of the prime activities. Recently, PRL has developed and delivered payloads for Chandrayaan-2 mission. Observations from these instruments will provide insights into the elemental composition of lunar rocks and soil and lunar thermal behaviour. In addition, several other important instruments are being developed for upcoming planetary missions of ISRO, to address several outstanding issues related to planetary science. Facilities to simulate planetary environments are available in PRL and larger ones will be developed. Laboratory studies of planetary samples and meteorites are carried out at state-of-the-art experimental facilities established in the division such as NGMS, MC-ICPMS, LA-ICPMS, Nano SIMS, EPMA and XRF. Petrological, morphological, chemical composition and isotopic studies of samples are used to characterize past and contemporary processes in the solar system. Important scientific questions are addressed related to the early solar system, planetary surface science, impacts processes and planetary evolution.

Data from remote sensing of planetary bodies is used to study surface topography and morphology, the surface composition being determined through imaging spectroscopy and surface age through crater chronology. The objective is to understand geological processes, like impact cratering, volcanism, tectonism, and space weathering. Theoretical models are developed to understand physical and chemical processes of ionospheres and atmospheres of planets and comets. These models are used to study the effects of dust storms, meteors, solar flares and CMEs on the Martian ionosphere. Climate change on Mars is also being studied using a general circulation model and long-term satellite data. The work related to interplanetary dust and astrochemistry is also being carries out.

GeoSciences

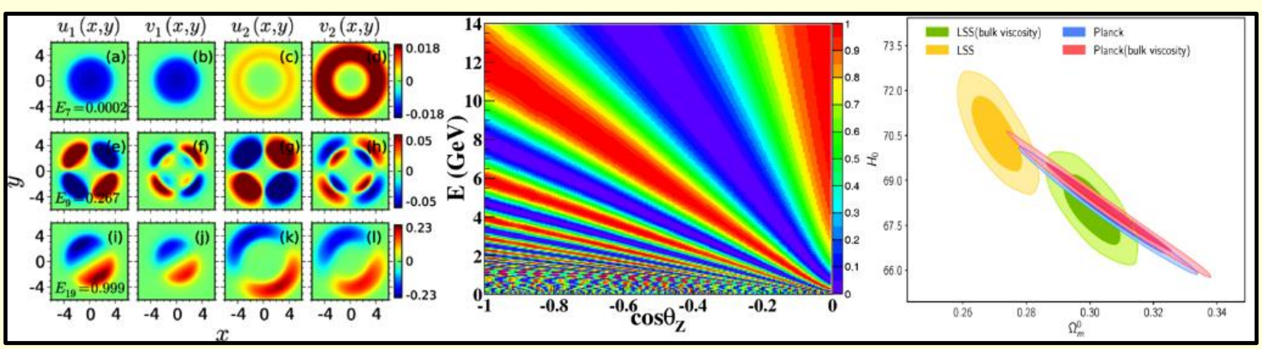
The research activities in the Geosciences are focused on understanding the origin and evolution of the planet Earth and its various components, with special emphasis on time scales and processes. Frontline research areas in geosciences are encompassing the five broad themes viz: (1) Solid Earth Studies; (2) Aquatic and Terrestrial Biogeochemistry; (3) Paleo climate; (4) Isotope Hydrology; and (5) Aerosol Chemistry. The research methodologies employed to pursue the research in Geosciences include field observations and laboratory measurements of abundances of elements and isotopes, both stable and radioactive, and thermal & optical luminescence properties of materials using modern analytical tools and state-of-the-art instruments.

Most of the Geoscience research requires extensive field work for field observations and collection of required samples from various geological and environmental reservoirs and repositories (geological formations, cave deposits, tree rings, coral reefs, terrestrial and oceanic sediments, seawater, groundwater, river water, estuaries, rain, snow, atmospheric moisture and aerosol). The spatial domain of research in Geosciences spans from deep crustal to atmospheric processes and the time domain ranges from geological processes operating on a timescale of millions of years to atmospheric processes varying on sub-hourly time scales. The inferences drawn are based on evidence ranging from visual observations of large scale geomorphological, structural and geological features in the field to precise measurements of isotopic and chemical composition in the laboratory using various modern instruments.

Atomic, Molecular and Optical Physics

Atomic, Molecular & Optical Physics research activities are going on in different domains that encompass Earth sciences, planetary sciences, classical and quantum optics, atomic and molecular physics and physics beyond the standard model. In a sense, it is a microcosm of PRL. Being interdisciplinary by nature, it covers a wide range of topics starting from foundations of quantum mechanics to astrochemistry. Along with classical and quantum properties of light, scientists investigate atoms, molecules, molecular clusters or condensed matter systems using the vast range of electromagnetic spectrum and other sources like high energy electrons and charged ions for basic as well as applied research. However, all the theoretical and experimental activities in this area can be categorised under the themes: (i) Atomic and Molecular Physics, (ii) Optical Physics, (iii) Luminescence Physics and Applications and (iv) Astrochemistry. To support the cutting-edge research in these areas, the PRL has state of the art laboratories for quantum science and technology, photonics, luminescence dating, low-temperature astrochemistry, laser-induced breakdown spectroscopy and attosecond physics.

Theoretical Physics



The activities in the area of theoretical physics span a wide range from sub-atomic particles to phenomena at the cosmological scales. The primary focus is to understand the very microscopic laws governing different physical phenomena. In particular, the focus is to delve into the study of fundamental particles and their interactions, properties at extreme conditions, the physics of the very early universe and addressing cosmological questions, high-temperature superconductivity and cold atoms.

The elementary particles interact via interactions or forces that are described by the standard model of particle physics. Although extremely successful, there are strong reasons to believe for the existence of new particles or forces beyond the standard model. To name a few, neutrino oscillations unambiguously implying a nonzero mass of neutrinos, matter anti-matter asymmetry observed around us and concrete evidence of dark matter and dark energy, both together constituting about 95% of the energy budget of the universe. These call for going beyond the standard model of particle physics and suggesting ways to look for these new particles and forces, be it at terrestrial experiments, like particle colliders and accelerators or astrophysical and or cosmological observations. On a more macroscopic scale, the focus is to explain the very bizarre properties shown by the high-temperature superconductors, in particular, the anomalous properties observed in unconventional superconductors. The advent of laser technology has paved the way to study individual atoms or a small bunch of them in a controlled way. This allows studying deep questions about quantum phase transitions, which are analogous to liquid to vapour transition in case of water.

All of these require analytic calculations, supplemented with state of the art numerical computations, simulations and analysis of data from various experiments, all of which are carried out in house at PRL.

PRL is a unique centre of excellence where research on such a wide range of themes ranging from interior of the Earth, Solar system, Stars, Galaxies to Universe are pursued under one roof.

National and International Acclaim

PRL alumni have played a key role in the development of institutions and programmes in India and abroad. The Indian Space Research Organization (ISRO) was nucleated in PRL and two of the past ISRO Chairmen, Prof. U.R. Rao and Prof. K. Kasturirangan are distinguished alumni of PRL. The Institute of Plasma Research (IPR) was nucleated by the erstwhile Plasma Physics Programme (PPP) group at PRL.

Numerous books on contemporary topics have been authored and edited by PRL scientists.

Facilities at PRL

Computer Centre

PRL Computer Centre is equipped with Vikram-100 High-Performance Computer Cluster which supports scientists, researchers and research scholars at PRL who require high-performance computing.

PRL has 1Gbps Internet connectivity through National Knowledge Network (NKN) Optical Fiber Cable (OFC), and 1Gbps through BSNL OFC.

Library

The library plays a crucial role in facilitating research in the laboratory by making available latest books, journals, e-journals in the respective areas. RFID and Wi-Fi enabled PRL Library subscribes to full-text databases, like AGU Digital Library, PROLA, GSA Archive, Nature archive (access from 1987) and Science Archive. IEEE Digital Library, SPIE Digital Library and AIAA Journals are made available through Antariksh Gyan – ISRO Libraries Consortium.

Recently, the library has started to carry out a similarity check using the iThenticate software. The PRL Library maintains an institutional repository which consists of journal articles published by the PRL authors from 1990 to present and is also linked through the Library homepage. All the PRL theses from 1952 onwards are now available electronically. All the PRL Technical Notes since 1977 have been digitized and are available for users. The E-books can be accessed through the library homepage.

Workshop

PRL Workshop is a state-of-the-art mechanical workshop that provides extensive support to scientists and engineers. The workshop is used to design, develop and fabricate suitable components, devices, attachments, adaptors or the entire instruments to support the research work. The workshop has a wide range of machines, from conventional ones to High-tech CNC. Over the years newer instruments are added and also the facilities are developed at other campuses of PRL.

Distinguished Professorships

PRL hosts prestigious Vikram Sarabhai Professorship and K. R. Ramanathan Professorship, under which eminent scientists are invited for lectures, popular talks and academic stays for extended durations. Several Nobel Laureates have graced these professorships. PRL also hosts visiting positions under various national and international exchange programmes.

Doctoral and Post-doctoral Programmes

PRL has contributed significantly to the scientific manpower development in the country through Doctoral (PhD) and PostDoctoral programmes. PRL attracts highly motivated students to pursue doctoral research in several branches of Theoretical Physics, Space and Atmospheric Sciences, Astronomy, Astrophysics and Solar Physics, Atomic, Molecular & Optical Physics, Planetary Sciences, and Geosciences. Students are trained through rigorous course work followed by a research programme leading to a PhD degree. The Post-Doctoral programme at PRL also attracts young researchers to work on research themes of complementary interests.

The fellowships at PRL compare with the best in the country. Details of these programmes are available on the PRL website. It can also be obtained from the Head, Academic Services, PRL.

Capacity Building Programmes

UN course on Space Sciences

Under the auspices of the Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) affiliated to the United Nations, PRL has been organizing Post-Graduate Course in Space & Atmospheric Science every alternate year since 1998. Participants from the Asia-Pacific region have been attending this course.

RESPOND programme

On behalf of ISRO, PRL administers the RESPOND programme (Sponsored Research) in Space Sciences. The main objective of the RESPOND programme is to establish strong links with academic institutions in the country to carry out research and developmental projects, which are of relevance to Space Sciences. RESPOND provides funding to academia in India for conducting research and development activities particularly in the fields of Astronomy and Astrophysics, Astrochemistry, Cosmology, the Physics of Earth's atmosphere, ionosphere magnetosphere, Planetary and Interplanetary Space Physics, Solar Physics, Space Weather and Space Plasma Physics. Through the RESPOND projects, it is expected to derive useful outputs of such R&D to support ISRO programmes. It is also aimed to enhance academic base, generate human resources and infrastructure at academic institutes to support the space programme of India. In order to facilitate the faculty of universities and Institutes to prepare suitable proposals of relevance to space programme, a detailed list of R&D areas/sub-areas/topics have been evolved as per major programmes of ISRO, by the various centres of ISRO and published at https://www.isro.gov.in/research-and-academia-interface.

Programmes for Students and Teachers

A summer internship programme for students and college and university teachers is organized to provide them with hands-on experience in research methodologies in various disciplines.

This programme is organized during May-July every year and is meant for BSc (final)/MSc First-year students in Physics, Chemistry, and Geosciences. The programme for teachers is meant for those involved in teaching Physics and Geosciences at the graduate and postgraduate levels and having an interest in pursuing research.

Project Training Programmes

PRL offers project training for Science and Engineering students. In addition, trainees are also taken in the Computer Centre, Workshop, Library, and Engineering Services and at Mt. Abu and Udaipur observatories. Additional information on academic and training programmes and relevant application forms are available on the PRL website.

Interactions with Society

PRL values its interaction with society and organizes science exhibitions and Open Houses periodically to inform society about its programmes, contributions and the excitement of pursuing science. Outreach events and popular talks are arranged from time to time on topical events of cutting edge research.

PRL celebrates the National Science Day by holding a series of programmes that include a science quiz and lectures for high school students and teachers. PRL scientists also visit schools and colleges, Universities in different cities and organize Open House Science Exhibitions from time to time. Celebration of World Space Week with a special emphasis on encouraging students from a rural background is another salient feature of PRL's outreach programme.

“Developmental tasks continually require decision-making based not on administrative procedures and precedents, nor even on economic models by themselves, but on the appreciation of hard realities related to science and technology in the context of our social environment. “- Dr. Vikram A. Sarabhai, August 1967.

Joint Inaugural Function of the 11th CSSTEAP Courses on Satellite Meteorology And Global Climate & Space And Atmospheric Science

The Eleventh Post Graduate Courses on (i) Satellite Meteorology and Global Climate and (ii) Space and Atmospheric Science, under the aegis of the UN-affiliated CSSTEAP, are being conducted at Space Applications Centre (SAC), Bopal Campus, Ahmedabad during August 1, 2018, to April 30, 2019. Twenty-six participants representing nine countries of the Asia Pacific region are attending the Courses.

A joint inaugural function of the two courses: (i) Satellite Meteorology and Global climate conducted by Space Applications Centre (SAC) and (ii) Space and Atmospheric Science conducted by Physical Research Laboratory (PRL) was held at K. R. Ramanathan Auditorium of PRL on 6th August 2018. Shri D K Das, Director of SAC, Dr. Anil Bhardwaj, Director of PRL, Dr. Senthil Kumar, Director of CSSTEAP, Dehradun and senior officers from SAC and PRL graced the function.

Dr. Anil Bhardwaj welcomed the participants, presented a brief overview of PRL and gave the students an idea of what to expect from this course. The participants from distant countries and varied cultures gave a brief introduction about themselves, their professional background and their aspirations from the course. Dr. Senthil Kumar gave an overview of the CSSTEAP Programs. Shri D K Das gave the inaugural address and observed that this is not only a golden opportunity to learn advanced subjects like Satellite Meteorology and Space Science, but also to learn about India and her diverse cultures. He also emphasized on the concept of “Vasudhaiva Kutumbakam”, meaning “the world is one family”. He also stressed that teachers can give you 25 %, you have to make the 25% from your own intellect, 25% you get form your friends, and the remaining 25% will come from your experience.

The common orientation module of both the courses began in the afternoon.

SAS-11 Academic Activities: An Overview

J. Banerji
Course Director

The Eleventh Post Graduate Course on Space and Atmospheric Science (SAS-11) began on August 1, 2018, at Space Applications Centre (Bopal Campus). There are 13 participants: 3 from India, 2 from Myanmar, 6 from Mongolia, and 1 each from Nepal and Uzbekistan. A joint inaugural function of this course, hosted by Physical Research Laboratory (PRL), and the Eleventh Satellite Meteorology and Global climate course (SATMET-11), conducted by Space Applications Centre (SAC)), was held at K.R. Ramanathan Auditorium, PRL on August 6, 2018. Shri D K Das, Director SAC, Dr Anil Bhardwaj, Director, PRL, and Dr. Senthil Kumar, Director CSSTEAP, Dehradun and senior officers from SAC and PRL graced the function.

The course started with introductory lectures common and useful to both SAS and SATMET participants. In this common module, very interesting talks were given by the faculty members from PRL, SAC and IIRS. The regular course began immediately after the common module was over. The course was spread over two semesters. Faculty members included eminent Scientists/Engineers from PRL and other Institutions in India. Subjects covered in the 1st semester were Earth's Atmosphere and Climate Change, Ionosphere and Radio Communication, Planetary Science and Exploration, Ground-Based Experiments for Near-earth Environment, and Space Instrumentation. Classroom lectures were delivered during the morning hours and relevant practicals were conducted in the afternoon sessions. For each of these subjects, there were tests, assignments and short seminars which were graded and used for internal assessment of the students. Lectures for the first semester ended on November 1, 2018. Final examinations for the first semester were conducted during the period November 5-14, 2018.

The SAS-11 participants attended the 15th International Symposium on Equatorial Aeronomy (ISEA-15), hosted by Physical Research Laboratory (PRL), Ahmedabad, India during October 22 – 26, 2018. This symposium allowed them to know the current status of research in the field of space physics, in general, and equatorial aeronomy, in particular. Several of the topics covered in ISEA-15 were taught as part of the curriculum of UN Space and Atmospheric science course and so the SAS-11 participants benefitted a lot from this opportunity.

As a part of the programme, the students were taken on a scientific tour during the period November 15-27, 2018, to selected national centres of excellence in Space and Atmospheric Science. We visited Alibag Magnetic Observatory run by Indian Institute of Geomagnetism, National Remote sensing Centre (NRSC) and TIFR balloon facility at Hyderabad, National Physical Laboratory (NPL) at Delhi and Andhra University, Vishakhapatnam for the mandatory document verification.

Classes for the second semester began on December 3, 2018, and ended on January 22, 2019. There were 4 theory papers covering topics on Sun and Space Weather, Stellar and Galactic Astronomy, Electronic Devices and Detectors for Space Instrumentation, and Space Exploration.

Final examinations for the second semester were held during January 25-February 1, 2019. Immediately thereafter, the students participated in ISRO- STP (Structured Training Programme) at PRL during February 4-8, 2019. The theme of this STP was "Recent Advances in Scientific Research in the Earth, Planetary and Space Sciences using Ground and Space-based data: Global Perspectives". This STP covered a variety of fascinating topics on Earth, Planetary and Space Sciences and utilization of ground and Space-based observations. After attending the STP programme, the students went on a scientific tour to Udaipur Solar Observatory and the infra-red observatory at Mt. Abu during February 10-14, 2019. From February 15, 2019, pilot projects started. Each student chose a topic of her/his research interest and pursued the research under the guidance of a faculty of PRL. The pilot project topics were as follows:

1. Solar Cycle and seasonal variations of the critical frequency and height of maximum ionization of F2-layer over Ahmedabad
2. Remote Sensing of the Moon
3. Analytical modelling of the solar coronal magnetic field
4. Long term trends of temperature and pressure data in Mongolia
5. Long term trends of precipitation in Mongolia
6. Surface ozone in an urban atmosphere
7. Asteroids and Comets
8. Space debris and their impacts
9. Investigation of Thermophysical Properties of Lunar Analogues by Laboratory Measurements
10. GEANT4 simulation for the Silicon detectors in ΔE-E mode
11. Modal and structural analysis of quadrupole mass spectrometer
12. Study of the solar origin of low-frequency radio bursts observed by the e-CALLISTO network
13. Classifying Supernovae using their optical spectra

The pilot projects were evaluated on April 12, 1919, when each student gave a short presentation of her/his project work in front of an expert committee.

Course Contents

DETAILS OF THE INDIVIDUAL THEORY PAPERS

SEMESTER 1

SAS.101 Earth's Atmosphere and Climate Change (40 hrs)

1.1 Concepts of Earth's Atmosphere (10 hrs)
Basic Structure of Atmosphere - Hydrostatic Equilibrium - Scale Height - Geopotential Height Thermodynamic Considerations – Elementary Chemical Kinetics – Composition and Chemistry of Lower, Middle and Upper Atmosphere - Thermal Balance in Thermosphere.

1.2 Effects of Solar Radiation on Atmosphere (5 hrs)
Solar Radiation at the Top of the Atmosphere – Attenuation of Solar Radiation in the Atmosphere – Radiative Transfer – Thermal Effects of Radiation – Photochemical Effects of Radiation

1.3 Aerosols, Greenhouse Gases and their effects on Radiation Budget and Climate Change (15 hrs)
Aerosols & Radiation Budget - Long Term Climate Impact - Black Carbon & Dust- Greenhouse Gases - Carbon monoxide - Carbon dioxide - Oxides of Nitrogen - Methane – Atmospheric Ozone – Ozone Chemistry – Ozone Hole.

1.4 Dynamics of Earth's Atmosphere (10 hrs)
Equation of Motion of Neutral Atmosphere – Thermal Wind Equation – Elements of Planetary Waves – Internal Gravity Waves and Atmospheric Tides – Fundamental Description of Atmospheric Dynamics and Effects of Dynamics on Chemical Species

SAS.102 Ionosphere and Radio Communication (40 hrs)

2.1 Structure and Variability of Earth's Ionosphere (13 hrs)
Introduction - Chapman's Theory of photo-ionization – Continuity equation and photo-chemical equilibrium – Loss processes - α and β Chapman layers - Chemistry of E and F1 regions - D region chemistry – Water cluster ions and their significance - Electron attachment and negative ions in the D region - F region processes – F layer splitting - Vertical transport - Ambipolar diffusion and F2 peak - Topside ionosphere – Diffusion between ionosphere and protonosphere - Morphology – diurnal, seasonal and solar cycle variations of ionospheric regions - F- region anomalies - SIDs

2.2 Ionospheric Plasma Dynamics (13 hrs)
Properties of magnetoplasma – Gyro frequency - Plasma frequency - Debye length and Frozen in field - Basic fluid equation - Steady-state plasma motions due to applied forces - Electrical conductivity of the ionosphere - Generation of electric field and electric field mapping - Ionospheric dynamo - Ionospheric irregularities – Equatorial Spread F and Equatorial Electrojet (linear theories) - Mid-latitude ionospheric irregularities – Sporadic E

2.3 Electromagnetic Wave Propagation in Ionosphere (14 hrs)
Theory of Wave propagation - Properties of plane waves in isotropic and anisotropic media - Group propagation - Ray and group velocities - Radio waves in ionized media – Propagation in isotropic plasma and refractive index - Concepts of critical frequency and virtual height - Magnetoionic theory – Appleton-Hartree formula for refractive index - Ordinary and extraordinary waves - Reflection conditions - Deviative and nondeviative absorption formulas - Oblique incidence propagation – MUF and skip distance.

SAS.103 Planetary Science and Exploration (40 hrs)

3.1 Atmospheres of other Planets and Satellites (10 hrs)
Inner and outer planets - Structure and Composition of atmospheres planets (e.g. Jupiter, Mars, Venus and Saturn) - their important Satellites

3.2 Ionospheres of Planets and their Satellites (10 hrs)
Ionospheres and magnetospheres of solar planets (Mars, Venus, Jupiter, Saturn etc.) and those of natural satellites (e.g. Titan), Extra-solar planets and their search procedures

3.3 Solar System Objects and their Exploration (8 hrs)
Planets and satellites of the planets and their orbits - Structure and topography of planets and their satellites - Physical and chemical characteristics - Space imagery of planets and their environment – Exoplanets - Comets, asteroids and other minor bodies in the solar system - Their orbits, surface and composition - Comet and asteroid collisions

3.4 Data Analysis Techniques (12 hrs)
Data resources, Data processing, Error analysis - Time series – Fourier Transform – DFT – FFT –Least Square Method – Linear Fitting – Statistical test of Significance – Correlation – Chi-Square Test.

SAS.104 Ground-Based Experiments for Near-earth Environment (40 hrs)

4.1 Radio Antenna (12 hrs)
EM radiation - Small dipoles and Loops - Half wave dipole - Antenna Arrays - Reflector Antenna – Applications for Radio Astronomy - Transmission lines and Impedance Matching Techniques - Receivers and Transmitters

4.2 Radio sounding (12 hrs)
Ionospheric Absorption Techniques - Ionosonde - HF and VHF Radars – Coherent and Incoherent Scatter Radars (HF, VHF and MST) - Radio Beacon Techniques - Global Positioning System (GPS)

4.3 Optical Techniques (10 hrs)
Photomultipliers Tubes - Image Intensifiers – Lasers - Semiconductor Photonic Devices - Photo diodes - Avalanche diodes - Laser diodes & CMOS imaging detectors -– Imagers - Interference Filters and Etalons – Fabry Perot Interferometer - Filter Photometers – Lidar, - Aerosols, Trace Gases and Ozone measuring devices.

4.4 Airglow (6 hrs)
Airglow – Oxygen green and red line emission - Nightglow – Dayglow – Twilight Glow –– Applications of Airglow Measurements for Ionospheric Dynamics

SAS.105 Space Instrumentation (40 hrs)

5.1 Launch Vehicles, Satellites and their Orbits (5 hrs)
Principles of Rocketry - Rocket Motors - Solid and Liquid Fuel Rockets - Sounding Rockets - Cryogenic engines - Multistage Rockets - Satellite Launch Vehicles - Basics of Satellite orbits- Kepler's Laws – Sub-satellite Point – Orbital Parameters – Sun-synchronous and geosynchronous Orbits – Low-Earth Orbits

5.2 Attitude Control, Power and Thermal systems of Spacecrafts (10 hrs)
Attitude Sensors – Sun Sensors – Star Sensors – Earth Sensors – Magnetic Aspect Sensors- Accuracy – Spin Stabilization and Gyros – Control of Flight-path – Close-loop Guidance, Spacecraft Power System –Solar Cells and Panels – Primary and Secondary Batteries— Special Power Sources – Radioactive Thermoelectric Generators (RTG), Spacecraft thermal control techniques

5.3 Selection of Materials for Space-borne payloads (5 hrs)
Behavior of Materials in Space (Temperature, Pressure and Radiation) – Outgassing —Corona Discharge— Coating and Coating-compounds – Radiation Damage –Mounting of Subsystems – Structural and Mass Limitations – Carbon Fiber Reinforced Plastic (CFRP) - Honeycomb Structures — Effects of Vibrations and Shocks on Spacecraft Structures – Spacecraft Thermal Environments – Thermal Paints and Surface Finish

5.4 Reliability, Tests and Qualification of Payloads for Space Experiments (5 hrs)
Fabrication of Electronics – Subassemblies- Electromagnetic Compatibility—Checkout, Reliability Considerations and derating - Test and Evaluation - Thermovac tests - Vibration and shock tests

5.5 Telemetry, Tracking, Command (TTC) and Data Handling System (5 hrs)
Telemetry System – Signal Conditioner, Onboard Data Recorder, Telecommand – Encoder—Decoder—Pulse and Data Commands - RF Systems – Receivers, Transmitters and Antenna— Ground Segments – Real-time and Off-line — Tracking

5.6 In Situ Techniques on Space Platforms (10 hrs)
Langmuir Probe – Electric Field Probe – Ion Drift Meter – Retarding Potential Analyzers – Mass Spectrometers and Magnetometers – Satellite-based temperature measurement - Satellite Drag for Neutral Densities

SEMESTER 2

SAS.201 Sun and Space Weather (60 hrs)

6.1 Elements of Solar Physics (20 hrs)
Sun and its Atmosphere – Solar Magnetic field - Sunspots and Solar Cycles – Solar Flares, Coronal Mass Ejections (CME), existence and properties of solar wind – solar wind interaction with geomagnetic field and generation of magnetic disturbances in earth’s Ionosphere and Thermosphere System - Effects on Space and Ground-Based Systems

6.2 Origin of Magnetic Field of Earth (10 hrs)
Dipole Description of Geomagnetic Field –Local elements and their determination - Secular and Diurnal Variation of Geomagnetic Field – Determination of Geomagnetic Coordinates of Station

6.3 Magnetosphere of Earth (10 hrs)
Effects of Solar Wind on Planetary Magnetic Fields – Formation of Geomagnetic Cavity – Magnetopause – Magnetosheath and Bow Shock – Polar Cusp and magnetotail

6.4 Phenomena in Magnetosphere (10 hrs)
Structure and nomenclature of the magnetosphere and its parts - Plasmasphere and Van Allen Radiation Belts – Magnetotail Dynamics - Substorms, Aurorae and Storms -ionosphere-magnetosphere interactions - Magnetosphere of Other Planets

6.5 Space Weather and its Effects (10 hrs)
secular and diurnal variation of the geomagnetic field – effect of ionospheric currents on geomagnetic field variations Geomagnetic Storms – Sub-storms and Current Systems – Aurora

SAS.202 Stellar and Galactic Astronomy (40 hrs)

7.1 Introduction to Astronomy (10 hrs)
Celestial Sphere; Coordinate systems; Measurement of Time; Observable quantities; Continuum radiation from Stars; Terminology - Brightness, Luminosity, Magnitude scale, colour; Size and Distance; Stellar spectra - formation of spectral lines - line broadening - curve of growth; Local Thermodynamic Equilibrium - Saha's equation; Spectral classification of stars; HR diagram; Binary stars and determination of stellar parameters.

7.2 Introduction to Astrophysics (10 hrs)

Main sequence phase of stars - Energy sources; Equations for Stellar interiors - stability; Atmospheres of stars; Post-main sequence evolution of stars; Fate of stars at the late stages of evolution - Mass loss -Planetary nebulae - supernovae; Chandrasekhar limit - Degenerate core remnants - White Dwarfs - Neutron stars - Black Holes; Interstellar medium and Star formation; Galaxies and their classification; Hubble's law; Introduction to Active Galactic Nuclei and Gamma Ray Bursts

7.3 High Energy Astrophysical Processes and Phenomenology (12 hrs)

Radiation processes - Cosmic Rays – Composition, energy and origin - X-ray Sources - X-Ray Binaries - Supernova Remnants – Pulsars – Galaxies - Active Galactic Nuclei –Gamma-ray astronomy: Gamma-rays from Pulsars - Supernova Remnants, Active Galactic Nuclei - Neutrino astronomy - Gravitational waves and their detection

7.4 Basics of Radio Astronomy (4 hrs)

Different type of Radio Telescopes - Aperture Synthesis -Very Long Base Interferometers (VLBI)

7.5 Radio Sources (4 hrs)

Radiation Mechanisms, Radio Galaxies, Pulsars, Radio Catalogues

SAS.203 Electronic Devices and Detectors for Space Instrumentation (20 hrs)

8.1 Electronic Devices (10 hrs)

Semiconductor Devices- Junction diode, FET and MOS devices - Hall Sensors – Thermistors and Thermoelectric Sensors – Diodes and Photovoltaic cells-Power devices and Heat Transfer- Integrated Circuits- MSI,LSI and VLSI Devices- Programmable Devices-Operational Amplifiers and Active Filters – Instrumentation Amplifiers and Logarithmic Amplifiers - Voltage to Frequency and Frequency to Voltage converters- A/D and D/A converters, Power Controllers and Regulators- DC/DC converters, Semiconductor radiation detectors,

8.2 Detectors (10 hrs)

Charge Sensitive Amplifiers – Charge Coupled Devices- CCD and CMOS Imaging Devices- Channeltrons and Microchannel plates (MCP) - Image Intensifiers and Position Sensors

SAS.204 Space Exploration (40 hrs)

9.1 Space Missions (20 hrs)

Indian and foreign operating remote sensing satellites and their instruments - Vital instrument parameters and sensitivity of instruments - Examples of communication satellites and their instruments - limitations and sensitivity of instruments; Instruments and their capabilities on Atmospheric Science satellites like ENVISAT, Megha-Tropique - Instruments and sensitivities of Astronomy satellites – Hubble Space Telescope, Spitzer Observatory - Chandra X-ray Observatory, Rossi X-ray Timing explorer - Astrosat and Swift mission

9.2 Astronomical Instruments and Observing Techniques (20 hrs)

Reflection and Refraction of light- Lenses, Mirrors and Prisms – Magnifiers and Microscopes - diffraction and Interference of light- Diffraction gratings - Interference filters and Etalons- Image formation- Spherical and Chromatic Aberration- Correction of Aberration and Optimization- Characterization of Image - Modulation Transfer Function (MTF)- Image Resolution- Off the Shelf Optical Parts – Fiber Optics and its applications- Fiber Bundles and Fiber Cables for Imaging and Light Guides.Telescopes - Different types of telescopes - Angular resolution and Diffraction Limited Resolution - Image formation in a camera - Plate Scale - Observatories (Ground-Based & Space Based) - Focal Plane Instruments— Imagers - Photometers - Spectrometers – CCDs and their use in astronomy - Detectors for Optical, Infrared, UV, X-rays, and Gamma-rays - Effect of Atmosphere (Seeing and Scintillation)

Teaching Faculty

The lectures were delivered by experienced scientists from both PRL and other institutes. In what follows, we give a paper-wise list of faculty members, the sections they have taught and the number (given in the bracket) of one-hour lectures they have delivered.

Faculty from PRL
Prof. A. C. Das
Shri R. N. Mishra
Prof. Harish Chandra
Prof. S. Lal
Prof. U. C. Joshi
Prof. A. Ambastha
Dr. Y. B. Acharya
Prof. S. A. Haider
Dr. S. K. Sharma
Dr. S. Ganesh
Dr. L. K. Sahu
Dr. B. Sivaraman
Dr. Arvind Singh
Dr. Priyanka Ghosh

Visiting Faculty
Prof. R. K. Manchanda
Prof. M. Sankararaman
Prof. K. N. Iyer
Prof. A. Jayaraman
Dr. S. P. Seth

Paper	Section	Faculty	Hrs	Total
1	1.1 & 1.2	S. Lal	15	40
	1.3	A. Jayaraman	15	
	1.4	L. K. Sahu	5	
		Priyanka Ghosh	5	
2	2.1	K. N. Iyer	13	40
	2.2	K. N. Iyer	5	
		Harish Chandra	8	
	2.3	Harish Chandra	14	
3	3.1	S. P. Seth	10	40
	3.2	S. A. Haider	10	
	3.3	B. Sivaraman	8	
	3.4	S. K. Sharma	2	
		Arvind Singh	5	
		Priyanka Ghosh	5	
4	4.1	R. N. Mishra	12	40
	4.2	Harish Chandra	12	
	4.3 & 4.4	Y. B. Acharya	16	
5	5.1	R. N. Mishra	5	40
	5.2	Y. B. Acharya	10	
	5.3 to 5.6	R. N. Mishra	25	
6	6.1	A. Ambastha	20	60
	6.2 to 6.5	A. C. Das	40	
7	7.1 & 7.2	U. C. Joshi	20	40
	7.3	R. K. Manchanda	12	
	7.4 & 7.5	M. Sankararaman	8	
8	8.1 & 8.2	R. N. Mishra	20	20
9	9.1	Y. B. Acharya	20	40
	9.2	U. C. Joshi	14	
		S. Ganesh	6	

Common Module

The following topics were covered:

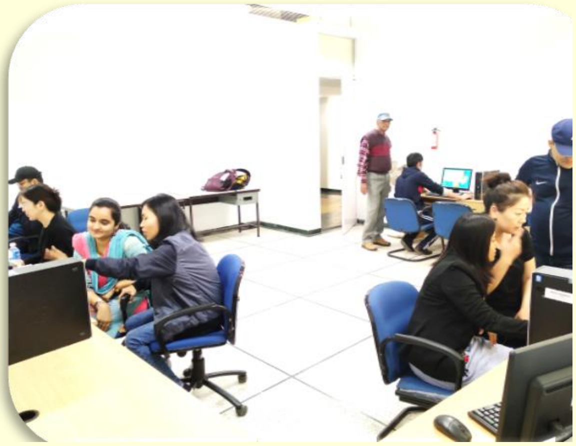
Faculty	Topic
Dr. S. Ganesh, PRL	EM Spectrum
Mr. D K Patel, SAC	Data Collection Platforms
Ms. Ruchi/Mr. Utkarsh, SAC	Computer Orientation-1, Visit to MOSDAC Data reception system
Dr. Senthil Kumar	Remote Sensing
Prof. U. C. Joshi, PRL	The Universe
Prof. S. Lal, PRL	Atmosphere
Prof. S. Ramachandran, PRL	Aerosols & Climate
Prof. Harish Chandra, PRL	Ionosphere
Prof. Janardhan, Dean, PRL	Solar Activity & magnetic field
Dr. Raghunath Bhattar, SAC	Introduction to Satellite Communications
Dr. Som Kumar Sharma, PRL	LIDAR
Ms. Rachana, SAC	About Library and Documentation
Dr. Abhijit Sarkar, SAC	Global Climate and Climate Change

Practicals

The following experiments were conducted during the course:

Sr. No.	Experiment	Supervisor(s)
1	Study of Ionosphere using Digisonde	Prof. Harish Chandra
2	The radiation pattern of Antenna (7-Element Simple dipole Yagi Antenna)	Mr. K S Modh and Mr. Rohit Dadhaniya
3	Study of Ultrasound Velocity	Mr. K S Modh and Mr. Rohit Dadhaniya
4	Determination of Planck's constant using LED	Mr. K S Modh and Mr. Rohit Dadhaniya
5	Measurement of Geomagnetic field	Mr. K S Modh and Mr. Rohit Dadhaniya
6	Study of different types of clouds over Ahmedabad using Raman Lidar	Dr. Som Kumar Sharma
7	The radiation pattern of Antenna (5-Element Folded dipole Yagi Antenna)	Mr. K S Modh and Mr. Rohit Dadhaniya
8	Study of Clouds over Ahmedabad using Ceilometers	Dr. Som Kumar Sharma
9	Measurement of O_3, H_2O and Aerosol optical thickness over PRL(Main Campus) using Microtop-II	Dr. Som Kumar Sharma
10	Total Electron Content measurements using GPS receiver	Mr. K S Modh and Mr. Rohit Dadhaniya
11	Surface measurement of Ozone using Ozone analyzer	Mr. S. Venkataramani
12	Study of the Diurnal characteristics of black carbon Aerosols over an urban location	Mr. T. A. Rajesh
13	Study of the Atmospheric density over Mt. Abu using Rayleigh Lidar	Dr. Som Kumar Sharma
14	Observation of celestial objects using 1.2 m IR telescope at Mt Abu	Mr. Vivek Misra
15	Study of Helioseismology at the Global Oscillation Network Group (GONG) site, USO, Udaipur	Dr. Brajesh Kumar
16	Study of solar activity and Sun's magnetic field by using the Multi-application Solar Telescope (MAST) at USO, Udaipur	Ms. Anisha Kulhari
17	Study of solar flares and coronal mass ejections by using the CALLISTO solar radio spectrometer at USO, Udaipur	Dr. Bhuwan Joshi
18	Measurement of Sun's Temperature	Mr. K S Modh and Mr. Rohit Dadhaniya
19	Study of Antenna Gain, Polarization, Inverse square law	Mr. K S Modh and Mr. Rohit Dadhaniya

Academic Activities at Bopal Campus



Pilot Projects

Sr. No	Name	Guide(s)	Project Title
1	Ms. Eram Khan	Prof. Harish Chandra and Dr. Som Kumar Sharma	Solar Cycle and seasonal variations of the critical frequency and height of maximum ionization of F2-layer over Ahmedabad
2	Ms. Gulfaroz K. Patel	Dr. Neeraj Srivastava	Remote Sensing of the Moon
3	Mr. Bhaskar Srinivasan	Dr. R. Bhattacharyya	Analytical modelling of the solar coronal magnetic field
4	Ms. Sedbazar Bayarmaaa	Dr. L. K. Sahu	Long term trends of temperature and pressure data in Mongolia
5	Ms. Munkhjargal Togtokhbayar	Dr. L. K. Sahu	Long term trends of precipitation in Mongolia
6	Ms. Jiguurtsetseg Purevdorj	Mr. S. Venkataramani	Surface ozone in an urban atmosphere
7	Mr. Batsuuri Batjargal	Dr. B. Sivaraman	Asteroids and Comets
8	Mr. Amarsaikhan Zorigoo	Dr. S. Vijayan	Space debris and their impacts
9	Mr. Batmunkh Batbayar	Dr. K. Durga Prasad	Investigation of Thermophysical Properties of Lunar Analogues by Laboratory Measurements
10	Ms. Hnin Ei Lwin	Mr. Shiv Kumar Goyal	GEANT4 simulation for the Silicon detectors in ΔE-E mode
11	Ms. Htet Htet Linn	Mr. Shiv Kumar Goyal	Modal and structural analysis of quadrupole mass spectrometer
12	Mr. Babu Ram Sharma	Dr. Bhuwan Joshi	Study of the solar origin of low-frequency radio bursts observed by the e-CALLISTO network
13	Mr. Alisher Kulmurodov	Dr. Vishal Joshi	Classifying Supernovae using their optical spectra

Pilot Project Students with their Guide(s)

Eram Khan

Gulfaroz K. Patel

Bhaskar Srinivasan

Sedbazar Bayarmaaa

Munkhjargal Togtokhbayar

Jiguurtsetseg Purevdorj

Batsuuri Batjargal

Amarsaikhan Zorigoo

Batmunkh Batbayar

Hnin Lwin & Htet Linn

Babu Ram Sharma

Alisher Kulmurodov

Solar Cycle and seasonal variations of the critical frequency and height of maximum ionization of F_2-layer over Ahmedabad

by

Ms. Eram Khan[1], Dr. Som Kumar Sharma[2] (Guide) and Prof. Harish Chandra[2] (Co-Guide)

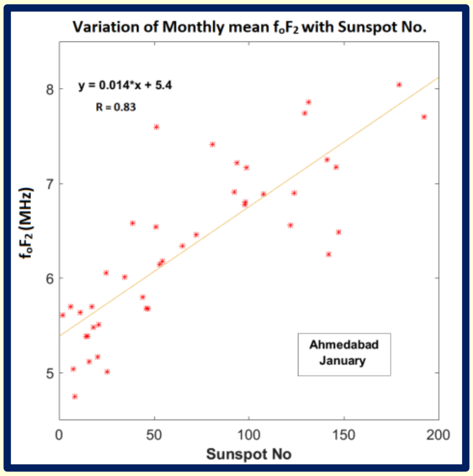
[1]Dept. of Physics, Andhra University, Visakhapatnam 530 003, India

[2]Physical Research Laboratory, Ahmedabad 380 009, India

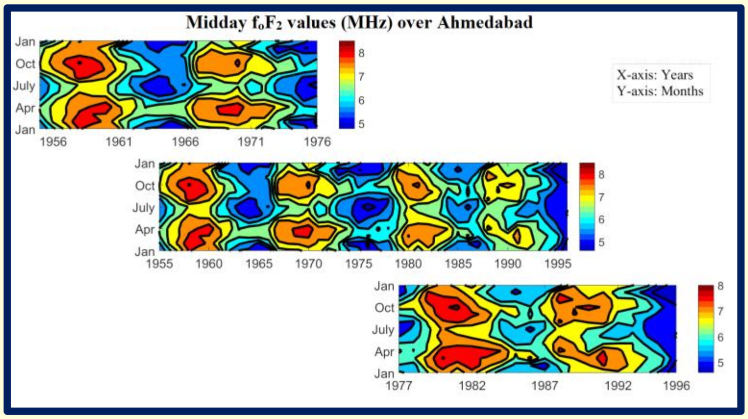
Abstract

Ionosphere primarily formed by the solar radiation shows regular daily, seasonal, solar cycle and latitudinal variations in the electron density. F_2 region is in addition, greatly controlled by the transport of ionization. Large electromagnetic vertical uplift of plasma from the F_2 region near the magnetic equator and subsequent diffusion along the geomagnetic field lines results in peak ionization at locations ±20^{O} magnetic latitude, known as Equatorial Ionization Anomaly.

Solar cycle and seasonal variations of f_oF_2 (critical frequency of F_2 layer related to the maximum electron density) and hpF_2, an indicator of the height of maximum ionization for Ahmedabad have been studied earlier for a solar cycle. Here we analyse data for the period 1955-96 to examine the seasonal and solar cycle dependence of f_oF_2 and hpF_2.



To study solar cycle variations, analyses are made for a fixed solar hour and for each month separately. This eliminates the daily and seasonal variations in the parameters. Plots of the time variations of f_oF_2, hpF_2 for midday (mean of 11-13 hour local time) and Rz for the period 1955-96 show good correlation. Correlation coefficients values and linear fits have been obtained for each month that describe the dependence of f_oF_2 and hpF_2 with Rz over Ahmedabad. Contour plots of the f_oF_2 and hpF_2 in the grid of months and years show both the seasonal and solar cycle variations.



Remote Sensing of the Moon

by

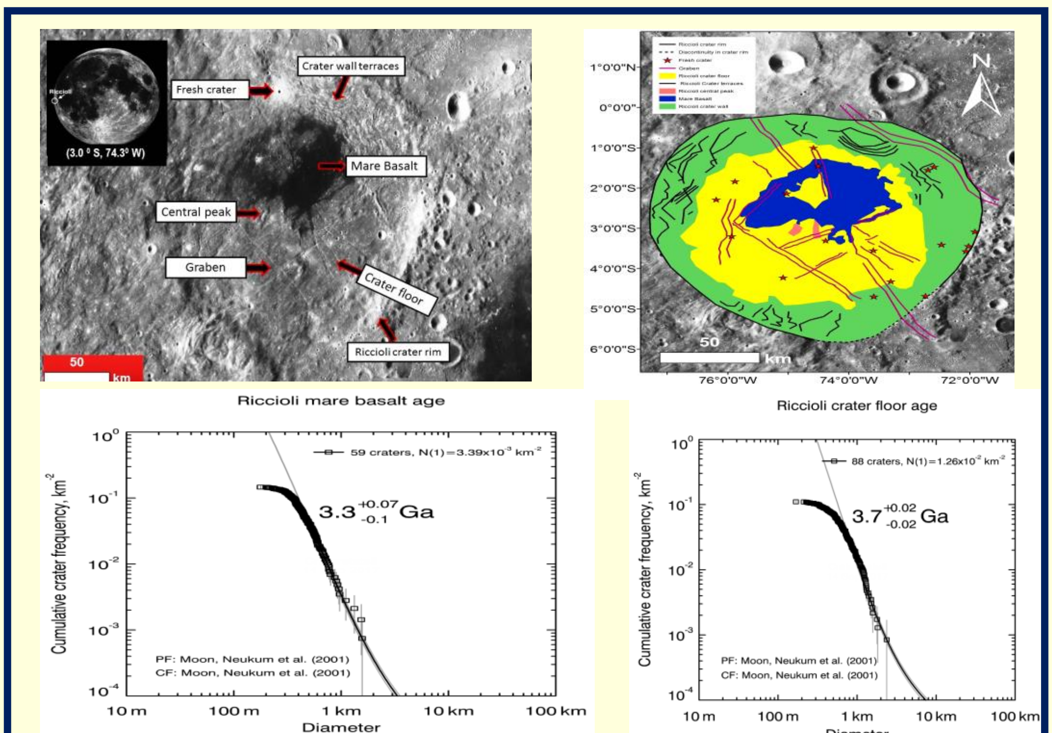
Ms. Gulfaroz Patel[1] and Dr. Neeraj Srivastava[2] (Guide)

[1]*Dept. of Physics, Gujarat University, Ahmedabad 380 009, India*

[2]*Physical Research Laboratory, Ahmedabad 380 009, India*

Abstract

The Moon is an astronomical body that orbits planet Earth and is the Earth's only permanent natural satellite. It is the fifth-largest natural satellite in the Solar System. The Moon is thought to have formed about 4.5 billion years ago, not long after Earth. The most widely accepted explanation is that the Moon formed from the debris left over after a giant impact between the Earth and a Mars-sized body called Theia. Since its formation, the Moon has experienced impact cratering and volcanism throughout its geological history, which has resulted in the highly cratered surface and formation of vast lava plains. In this study, we have investigated the geology of an impact crater on the Moon known as Riccioli crater using LROC WAC data from Lunar Reconnaissance Orbiter (LRO) mission of NASA, which is currently orbiting the Moon. Riccioli crater centred at (3.0 ^{0} S and 74.3^0 W) is a large lunar impact crater of diameter 146 km and depth 2.3 km. It is located near the western limb of the Moon in the immediate vicinity of the Grimaldi basin. We have identified the various geological units of the Riccioli crater and mapped them using ArcGIS software. Subsequently, Crater Chronology technique has been used to determine the age of the Riccioli crater and the mare basalt unit partially covering its crater floor. It has been found that the Riccioli crater formed ~3.7 Ga ago and the volcanism occurred inside the crater up to ~3.3 Ga.



Analytical modelling of the solar coronal magnetic field

by

Mr. Bhaskar Srinivasan[1] and Dr. R. Bhattacharyya[2] (Guide)

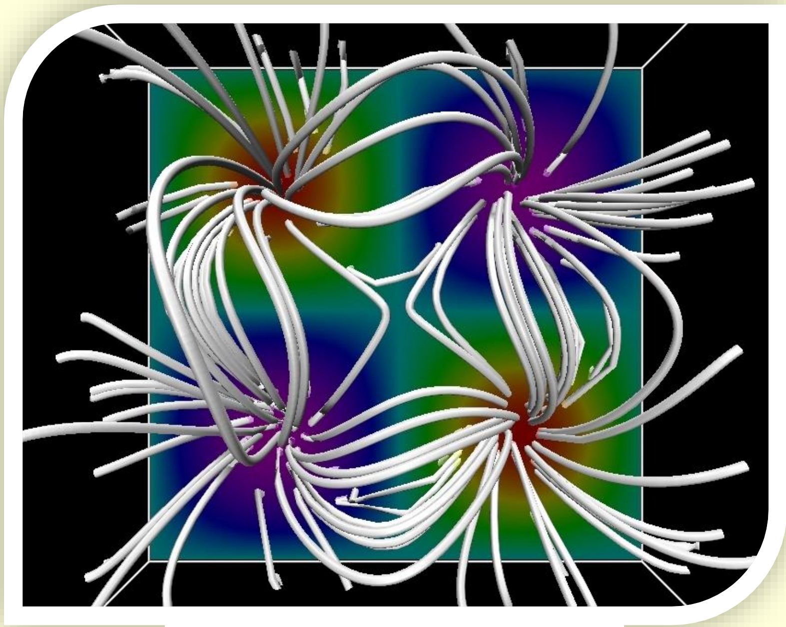
[1]*Dept. of Aeronautical Engineering, Tagore Engineering College, Chennai 600 127, India*

[2]*Udaipur Solar Observatory, Udaipur 313 001, India*

Abstract

Study of the magnetic field in the solar corona is of significance as it becomes an integral part of studying transient events like Coronal mass ejections, Solar flares etc. Coronal mass ejection involves catapulting plasma from solar corona into the Interplanetary medium at very high velocities; Solar flares are brightening of regions of solar disk resulting in Electromagnetic emissions in all possible wavelengths. All such events are accounted as different manifestations of processes which fundamentally involves a change in the magnetic morphology of the sun.

The fundamental difference between laboratory plasma and astrophysical plasma is that the Magnetic Reynolds Number is very high for astrophysical plasma which enables them to satisfy Alfven's Flux Freezing theorem, in which the identity of the magnetic field lines are preserved along the motion of the plasma as it evolves over time. This indicates that the dynamics of the plasma can be inferred from the dynamics of the magnetic field lines.



Twisted magnetic field lines

In the solar corona, the plasma β parameter (ratio of plasma pressure to magnetic pressure) is small, indicating that plasma pressure can be neglected in the corona. Thus, under equilibrium considerations, the Lorentz force (force due to magnetic interaction) is negligible which infers that the volume current density and Magnetic field are parallel to each other.

In this project, the equilibrium of coronal plasma is analytically modelled in 2D and 3D using appropriate equations. The magnetic field lines are obtained using Interactive Data Language(IDL) and Visualization and Analysis Platform for Ocean, Atmosphere and Solar Researchers (VAPOR).

Long-term trends of temperature and pressure data in Mongolia

by

Ms. Sedbazar Byarmaa[1] and Dr. L. K. Sahu[2] (Guide)

[1]Mongolian Meteorology And Ecology Society, Ulaanbaatar, Mongolia

[2]Physical Research Laboratory, Ahmedabad 380 009, India

Abstract

Mongolia is a landlocked country in central Asia and East Asia, located between China and Russia. The climate of Mongolia can be described to be severe and with strong regional and temporal variations. As part of this project, I have been doing an analysis of a long-term record of air temperature and atmospheric pressure data measured at 16 different stations of Mongolia from the year 1974 to 2015. In Figure 1, the time series of air temperature measured at 16 stations and their average values are shown. We can see, that the highest annual temperature (+7.7 ºC) was measured at Khovd stations in the year 2014, while the lowest temperature (-4.6ºC) was measured at Omnogovi station in the year 1984. The most important use of analyzing time series data is that it helps us to predict the future behaviour of the variable based on past experience. The short term changes in data are due to seasonal factors. I hope to complete a detailed analysis of both temperature and pressure data during the project.

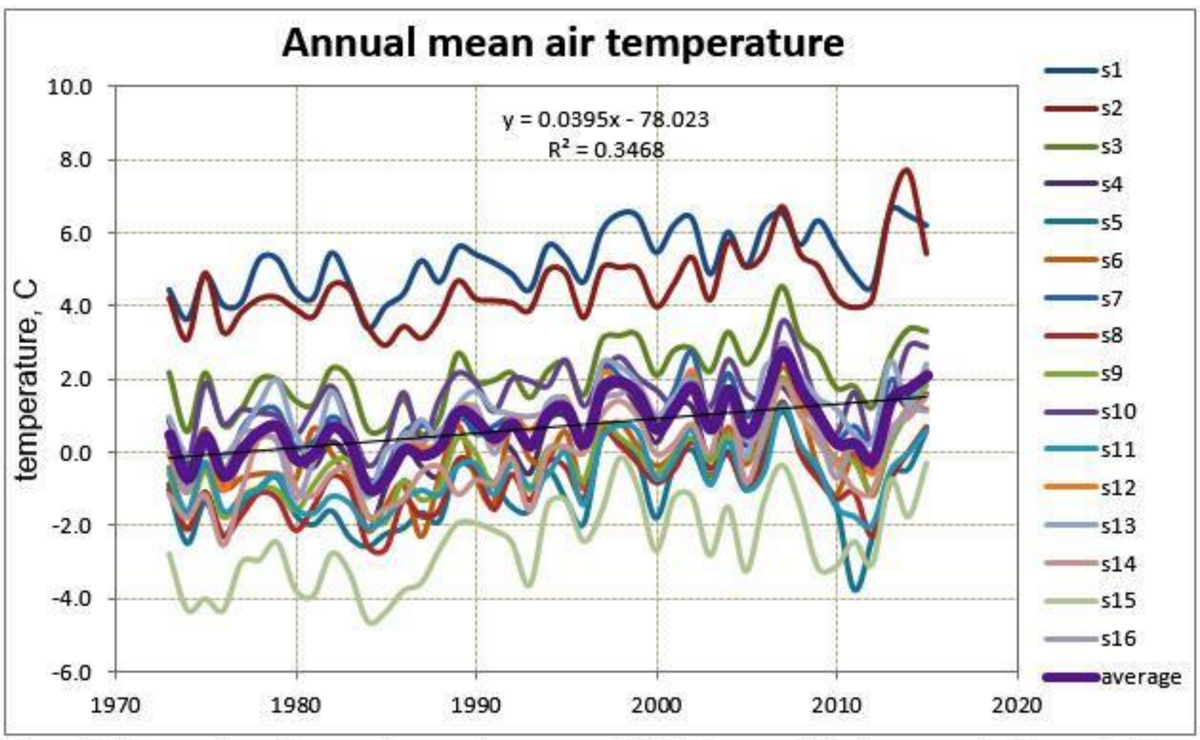


Figure1. Time series of temperature and pressure at 16 stations and their average in Mongolia from 1974-2015

Long-term trends of precipitation in Mongolia

by

Ms. Togtokhbayar Munkhjargal[1] and Dr. L. K. Sahu[2] (Guide)

[1]Mongolian Meteorology And Ecology Society, Ulaanbaatar, Mongolia

[2]Physical Research Laboratory, Ahmedabad 380 009, India

Abstract

Mongolia is situated in the central part of the Asian continent bounded on the north by Russia and on the east, south, and west by China. Mongolia has a high elevation with extreme continental climate conditions with a long cold winter and a short summer. Most of the precipitations occur in the summer season. About 85-90% of annual precipitations fall as rain in the summer season. Precipitation is highest in the north, which averages 200 to 350 millimetres (7.9 to 13.8 in) per year, and lowest in the south, which receives 100 to 200 millimetres (3.9 to 7.9 in). The southern Mongolia which is close to the Gobi desert receives very little or no precipitation during most of the months. As part of the project, I have analyzed the precipitation data recorded at 16 different stations in Mongolia during 1960-2017. The time series of annual total precipitation data are shown in Figure 1. The highest annual precipitation of 230 mm was measured at Bulgan station in the year 1975 while the lowest precipitation of 15.3 mm was measured at Sainshand station in the year 2005. The average data of all 16 stations show significant variation with highest of 108 mm for the year 1963 and lowest of 70 mm for the year 1965. I will present a more detailed analysis of the data during the project.

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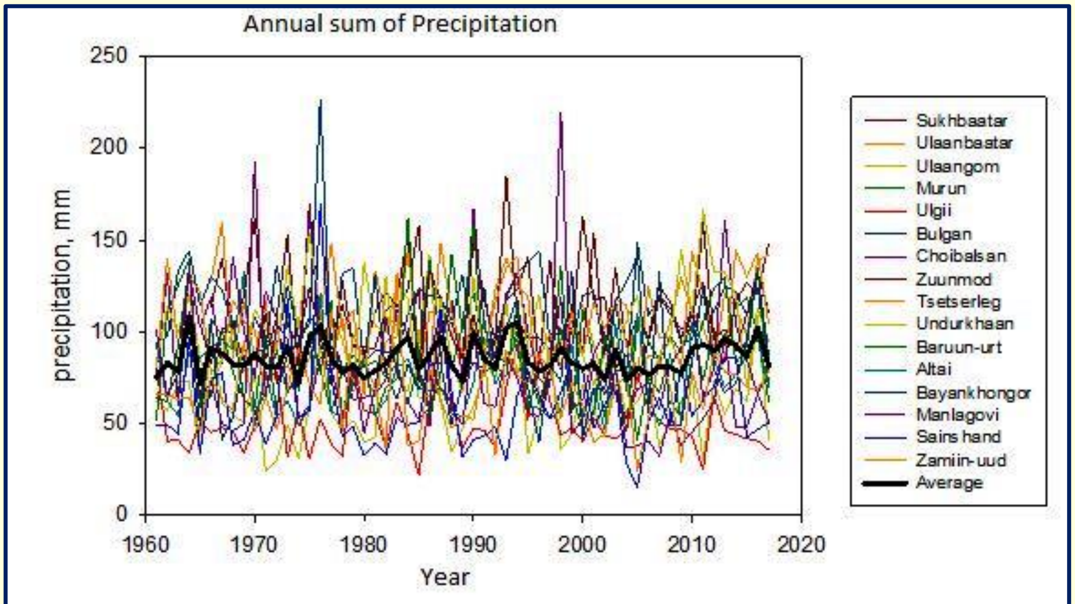


Time series of Precipitation at 16 stations and their average in Mongolia during 1960-2017

Surface Ozone in an urban atmosphere

by

Ms. Jiguurtsetseg Purevdorj [1] and Mr. S. Venkataramani[2] (Guide)

[1]Dept. of Meteorology, Hydrology and Environmental Monitoring of Selenge province, Mongolia

[2]Physical Research Laboratory, Ahmedabad 380 009, India

Abstract

Ozone is a necessity for the survival of living being as well as a pollutant with adverse effects, depending upon its amount and altitudinal placement in the atmosphere. In the troposphere, ozone is a greenhouse gas and its higher levels can even have deleterious effects on human health and plants. Ozone in the troposphere is mostly due to anthropogenic activity. Tropospheric ozone budget is governed by photochemical production and loss, transport from the stratosphere, and surface deposition. The overall reaction for ozone production is given by:

$CO/CH4/NMOC + NO_x$ + hv—› O_3 + other pollutants

Where: *NMOC*=non-methane organic compound, $NO_x = NO + NO_2$

The ozone analyser works on the basic principle of UV absorption (at 254 nm) and is given by Beer Lambert's law. The layout of an ozone analyzer is shown in Fig. 1. The data used in this work is for the period January 15-25, 2019 from Ahmedabad, an urban region in western India. Figure 2 gives the diurnal variation of ozone during this period.

The diurnal variation has the following few distinct features typical of an urban atmosphere:

a) Noon-time maximum - anthropogenic production from pollutants.

b) Low values in the night time - the absence of sunlight which inhibits the ozone production and loss from chemical reactions and dry deposition

c) Low values just after the sunrise – the destruction of ozone by sunlight

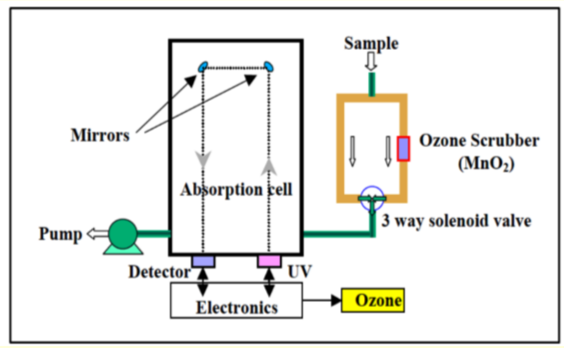


Fig. 1

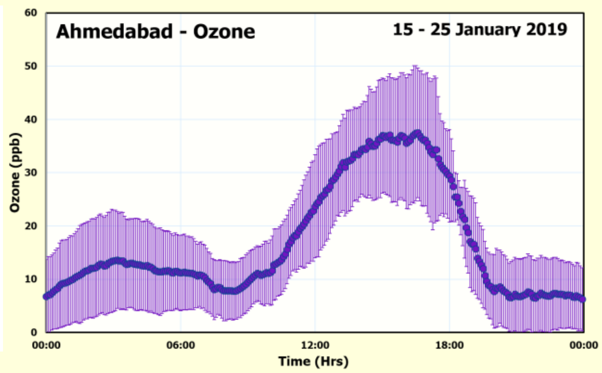


Fig. 2

Asteroids and Comets

by

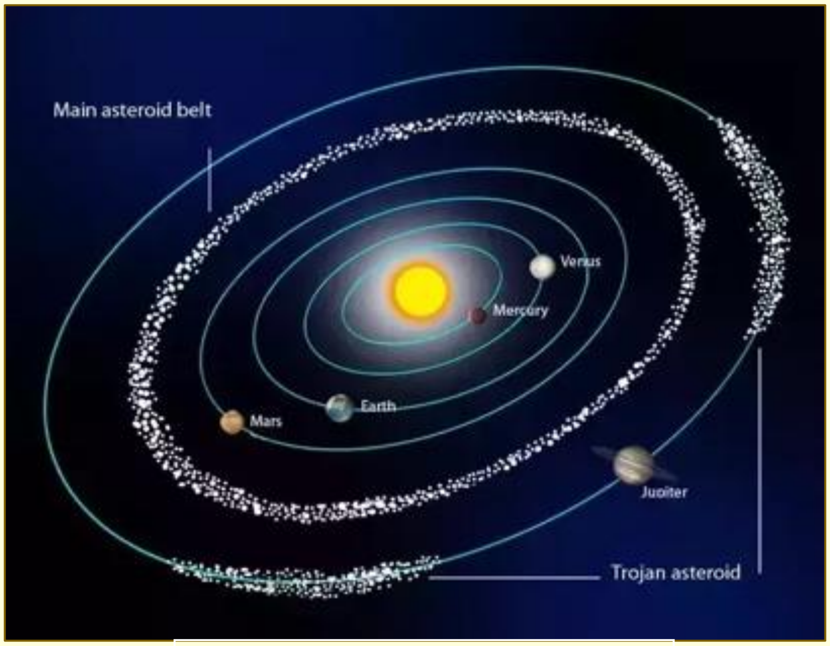
Mr. Batsuuri Batjargal[1] and Dr. B. Sivaraman[2] (Guide)

[1]The Institute of Astronomy and Geophysics, Ulaanbaatar, Mongolia

[2]Physical Research Laboratory, Ahmedabad 380 009, India

Abstract

The formation and evolution of the Solar System can be understood by studying the remnants of the early Solar system. The remnants could be comets, asteroids, Kuiper belt objects etc. The basic understanding of these smaller bodies in our Solar system; physical conditions of these bodies, chemical composition and the evolutions are the key to explore these bodies. There are differences between comets and asteroids on their composition and physical appearance. Apart from these bodies, there are other smaller bodies such as Trojan bodies corresponding to the Lagrangian points, that are present in the Solar System. These smaller bodies are studied through the telescopic observations, both ground and space-based. There are many dedicated missions that have been launched to understand these cometary and asteroids bodies. Details of physical conditions and chemical evolutions of a few of the asteroids and comets such as Ceres, Vesta, Eros etc. and comet 67P etc. have been carried out.



Asteroids

Comet

Space debris and their impacts

by

Mr. Amarsaikhan Zorigoo[1] and Dr. S. Vijayan[2] (Guide)

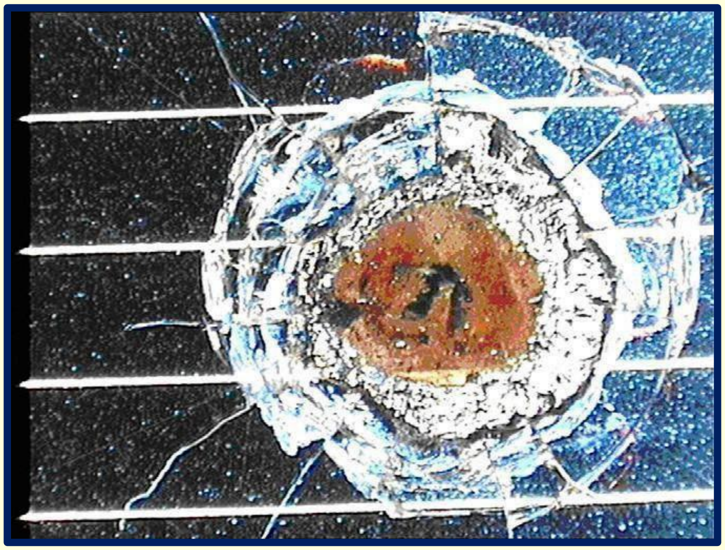
[1]The Institute of Astronomy and Geophysics, Ulaanbaatar, Mongolia

[2]Physical Research Laboratory, Ahmedabad 380 009, India

Abstract

On Earth's orbit, other than controlled satellites several pieces of debris are orbiting, and they are travelling at over 27,000 km/h. Such space debris size from sub-micron/micron-sized particles to few centimetre particles, which can degrade sensitive spacecraft surfaces, solar panels, mirrors, optical sensors and thermal control surfaces. There are estimated to be over 128 million pieces of debris smaller than 1 cm (0.39 in) as of January 2019. There are approximately 900,000 pieces from one to ten cm. This space debris can collide with and destroy essential satellites, knocking out communications and in turn creating even more debris. Such debris impact over any of the spacecraft surface area they result in an impact crater. These sizes are 1-100μm. This project is aimed to understand the effects of space debris using the Matlab software.

Beyond 4 km/s (depending on the materials), an impact will lead to a complete break-up and result in melting of the projectile, and ejection of crater material to a depth of typically 2–5 times the diameter of the projectile. These impacts create a shock wave in the target material and lead to very high pressures (>100 GPa) and temperatures (>10,000 K). The impacting object and the target material are fragmented or vaporized. For impacts with velocities, 1) up to about 5 km/s most of the ejected material are solid fragments, 2) Above 20–25 km/s the ejecta is completely vaporised, 3) Ejecta from impacts in the velocity range 5– 20 km/s are a mixture of solid fragments and molten droplets.



Impact crater on HST solar cell with a crater diameter of 4 mm

Investigation of thermophysical properties of Lunar Analogues by laboratory measurements

by

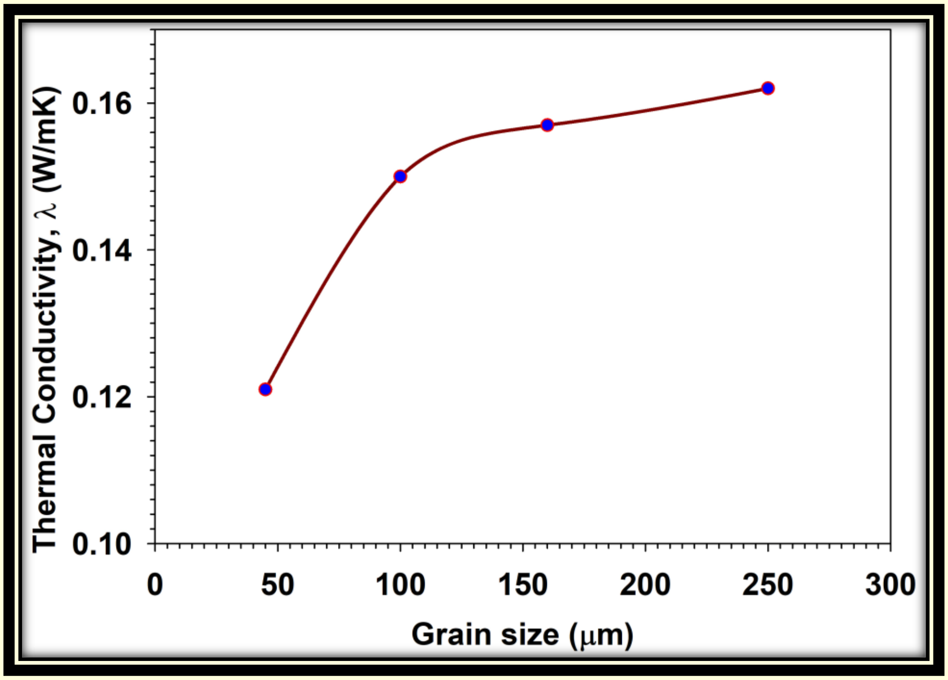
Mr. Batmunkh Batbayar[1] and Dr. K. Durga Prasad[2] (Guide)

[1]The Institute of Astronomy and Geophysics, Ulaanbaatar, Mongolia

[2]Physical Research Laboratory, Ahmedabad 380 009, India

Abstract

The thermophysical behaviour of the uppermost layer of the lunar surface is highly complex and is not well understood. The principal reason for this is the inter-dependence of various physical properties and the extreme temperatures and vacuum conditions of the Moon. The thermophysical properties of the lunar surface layer show significant variation as a function of various parameters such as pressure, grain size, density/porosity, stratigraphy, composition etc. In the present work, an attempt has been made to investigate the thermophysical properties of certain lunar analogous soils under laboratory conditions. The soil samples used for this work were terrestrial analogues of lunar basalt and anorthosites. Using a measurement setup based on transient line heat source method, the thermal conductivity and thermal diffusivity of the soil samples are obtained. Experiments were conducted for different grain sizes of both basalt and anorthosite samples. Results show a significant dependence of grain size on the on both thermal conductivity and thermal diffusivity values. One such variation for thermal conductivity is shown in the following figure.



GEANT4 simulation for the Silicon detectors in ΔE-E mode

by

Ms. Hnin Ei Lwin[1] and Mr. Shiv Kumar Goyal[2] (Guide)

[1]*Myanmar Aerospace Engineering University, Meiktila, Mandalay Division, Myanmar*

[2]*Physical Research Laboratory, Ahmedabad 380 009, India*

Abstract

GEANT4 is a Monte Carlo based toolkit to simulate the interaction of particles through matter. Geant4 incorporates various physics interactions, user-defined geometries, event-tracking system etc. GEANT4 covers a wide range of interaction energies (eV to TeV range) from optical to γ-rays and charged particles. It allows the user to define the experimental geometry, sample composition, incident beam type and its energy with direction and also to include the fundamental physics processes

A charged particle loses its energy in the detector by ionization at a rate determined in part by its velocity. The energy lost per unit distance is called as dE/dx. The ΔE-E technique for identifying the incident particle and measure its total energy involves a stack of two detectors of different thicknesses. The basic idea is that the incident particle deposits only a fraction of its energy in the first thinner detector whereas it is fully absorbed in the second thick detector, which is kept behind the second detector. Energy deposited in the detector of a given thickness depends on the mass of the particle. Thus, measuring the signal from both the detectors can provide information on the particle type and its energy.

The aim of the project is the data analysis of the energy loss in Silicon detector using Geant4 Simulation. Silicon detectors are very compact, demand low power, have high quantum efficiency and are insensitive to magnetic fields. The project focuses on the detection of energy on the Silicon detector in the range of 10 keV and 100 MeV. Silicon detector thickness is varied from 10 Microns to 1500 Microns to see the cut-off energy of the particles v/s detector thicknesses. Figure 1 presents the results with the variation of the thickness of 10 Microns while Figure 2 presents the results with the thickness and averaged value of deposited energy for all thicknesses of Si detector.

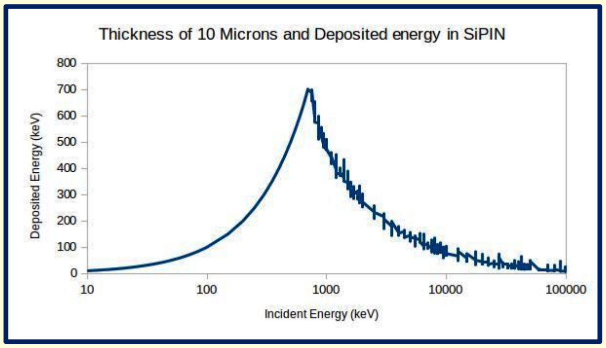


Fig. 1

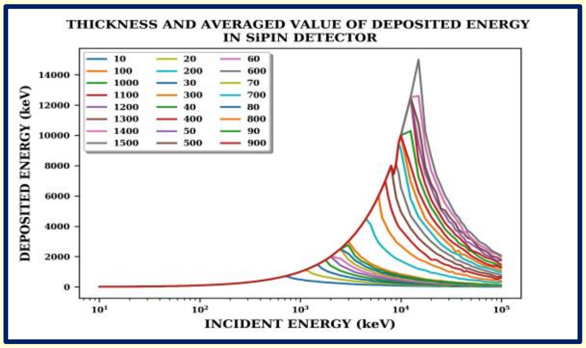


Fig. 2

Modal and structural analysis of Quadrupole Mass Spectrometer

by

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Abstract

Simulation modelling is the process of creating and analyzing of a physical model to predict its performance in the real world. It analyses by applying the simulation software. Using simulation software, we can optimize geometry for weight & strength and accordingly select materials for further improvement. The part failure analysis, load analysis can be simulated which is very difficult to test in a real scenario. The structural modal analysis uses the overall mass and stiffness of a structure to find the various periods at which it will naturally resonate. Modal analysis is a powerful tool to identify the dynamic characteristics of structures. Every structure vibrates with high amplitude of vibration at its resonant frequency. It is imperative to know the modal parameters- resonant frequency, mode shape and damping characteristics of the structure at its varying operating conditions for improving its strength and reliability at the design stage. The goal of a modal analysis is to determine the natural mode shapes and frequencies of an object or structure during free vibration.

Design of quadrupole mass spectrometers (QMS) requires precise alignment of the various mechanical parts like ionizer, ceramic spacers, quadrupole rods, detectors etc. QMS operates inside Vacuum, at the level of < 10^{-5} Torr. Any misalignment in the assembly may result in the wrong interpretation of the results. The QMS assembly has been designed in the Open-Inventor software and structural analysis being carried out. In order to understand the structural analysis, one cantilever was designed and analysis was obtained. Figure 1 shows the design of the cantilever and the stress coming on it. Design of the QMS assembly is shown in Figure 2.

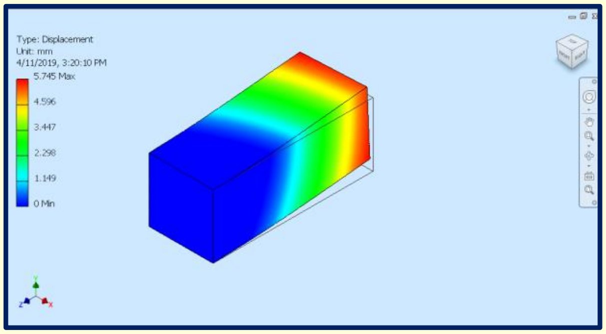

Fig. 1

Fig. 2

Study of the solar origin of low-frequency radio bursts observed by the e-CALLISTO network

by

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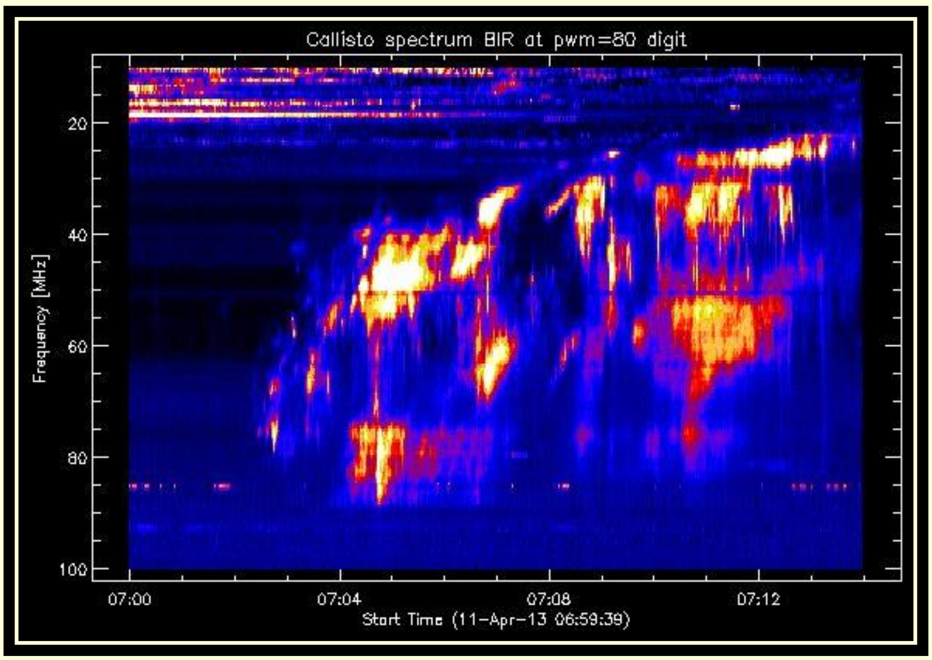
Abstract

The radio emission during a solar flare is often called radio burst. During such burst, Sun's radio emission can increase up to millions of times the normal intensity so they can outshine the entire Sun at radio wavelength. The solar radio bursts are very effective probes of the physical state of the magnetized solar atmosphere where flares and eruptions initiate and evolve.



Our study mainly focusses on the identification of different types of radio bursts observed by the e-CALLISTO network from January 2013 to December 2014 which corresponds to the maximum phase of the solar cycle 24. We first examined quick-look data available at e-CALLISTO website and found several radio bursts of different types during this period. For the piolet project, we have selected 10 radio bursts that show complex structures, i.e., more than one type of radio burst occurred simultaneously (see Figure). These representative events are found to be associated with GOES flares of classes C to X. For a detailed analysis, we constructed the high-resolution solar dynamical spectra of selected time and frequency ranges using Solar SoftWare (SSW) and Interactive Data Language (IDL). We have compared the radio data with soft X-ray observations from GOES satellite. To investigate the solar source origin of the radio bursts, analyses of solar images in white light, magnetogram, and EUV have been carried out. The comparisons of multi-wavelength measurements yield insights about processes responsible for the energy release and magnetic restructuring.

Classifying Supernovae using their optical spectra

by

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Abstract

A supernova is an event that occurs when certain types of stars die. Supernovae may expel most of the material away from a star at velocities of the order of few thousands to 10s of thousands of km/s driving an expanding and fast-moving shock wave into the surrounding interstellar medium. This shock sweeps up an expanding shell of gas and dust, which is observed as a supernova remnant. Astrophysical consequences of these Supernova events impact significantly on nearby surroundings and the interstellar medium. Supernovae create, fuse and eject the bulk of the chemical elements produced by nucleosynthesis. Supernovae play a significant role in enriching the interstellar medium with the heavier atomic mass chemical elements. The expanding shock waves from supernovae can trigger the formation of new stars. Theoretical studies indicate that the basic trigger mechanisms for supernova events are barely two:

1. The sudden re-ignition of nuclear fusion in a degenerate star: a degenerate white dwarf may accumulate sufficient material from a binary companion, either through accretion or via a merger, to raise its core temperature enough to trigger runaway nuclear fusion, completely disrupting the star.
2. The sudden gravitational collapse of a massive star's core: the core of a massive star may undergo sudden gravitational collapse, releasing gravitational potential energy as a supernova.

While some observed supernovae are more complex than these two simplified theories, the astrophysical collapse mechanics have been established and accepted by most astronomers for some time.

Astronomers have classified Supernovae into two main classes, type I and type II, according to their optical spectra. If a supernova's spectrum contains hydrogen lines it is classified Type II; otherwise, it is Type I. In each of these two types there are sub-classes according to the presence of lines from other elements or the shape of the light curve.

In this project, the student will learn to classify supernovae using their optical spectra. GELATO, a templet comparison software, have been used to compare optical spectra of supernovae with various templet spectra of supernovae of known classes.

Events at PRL

During the course, the SAS-11 students enthusiastically participated in various events organized at PRL.

Celebrations of (top) Independence Day and (bottom) Republic Day

Celebration of Vikram Jayanti, the birth anniversary of Dr. Vikram A. Sarabhai who founded the Physical Research Laboratory

Participation in International Women's Day

Participation in

National Science Day

Participation in ISRO-STP (Structured Training Programme)

With Shri A. S. Kiran Kumar at the15th International Symposium on Equatorial Aeronomy (ISEA-15)

Lab Visits


NATIONAL PHYSICAL LABORATORY

Tour Gallery