Astronomical Society of India (ASI) Symposium 003

on

Cosmic Vision 2047: Solar and Planetary Dynamics through Observations and AI/ML

8 - 10 September 2025

ABSTRACT BOOK

Jointly Organized by

Centre for Research in Environmental Sustainability & Department of Physics School of Sciences

JECRC University, Jaipur


JECRC
UNIVERSITY
Inaugurated By
Shri Ashok Gehlot
Chief Minister of Rajasthan
4th September 2012
in the presence of
Dr. Malcolm Portera
Former Chancellor, University of Alabama, USA
Shri Vivek Bansal
Secretary, All India Congress Committee
Shri OP Agrawal
Chairman, JECRC UNIVERSITY

MESSAGE FROM THE CHIEF MINISTER OF RAJASTHAN

सत्यमेव जयते

CHIEF MINISTER
RAJASTHAN

Message

I am delighted to know that JECRC University, Jaipur, is hosting the Astronomical Society of India Symposium (ASI Symposium 003) titled "Cosmic Vision 2047: Solar and Planetary Dynamics through Observations and AI/ML".

With the rapid progress in observational technologies, data analytics and artificial intelligence, our understanding of solar activity and its influence on planetary space weather is advancing at an unprecedented pace.

As India approaches 100 years of independence in 2047, our shared vision is to build a Viksit Bharat, an advanced, self-reliant and globally leading nation powered by innovation, knowledge and scientific excellence.

The title of ASI Symposium 003 reflects our nation's aspiration to be at the forefront of scientific discovery and technological innovation. By deepening our knowledge of solar activity, planetary dynamics and cosmic phenomena, this initiative aligns with India's vision of harnessing science and technology as a beacon for national progress and human advancement.

I am confident that this symposium will serve as a valuable platform to deliberate on recent advances in solar physics, Sun-planet interactions and space weather prediction. By emphasizing observations, theory and AI/ML applications, it offers an excellent opportunity to exchange knowledge and further strengthen research in this field.

I extend my warm greetings to all the participants and wish the symposium every success.

(Bhajan Lal Sharma)

Message from Shri Amit Agrawal Vice Chairperson, JECRC University, Jaipur

Dear Participants,

It gives me immense pleasure to welcome you all to ASI Symposium 003 – "Cosmic Vision 2047: Solar and Planetary Dynamics through Observations and AI/ML," hosted by JECRC University.

With a steadfast focus on quality education, innovation, and research, JECRC University prepares young minds to meet future challenges. The regular hosting of such academic platforms has become a distinctive hallmark of the University's academic journey.

This symposium represents an exciting confluence of science, technology, and innovation. By bringing together researchers and experts from across the country and abroad, we are not only celebrating India's achievements in missions such as Aditya-L1 and Chandrayaan-3 but also charting the course toward new frontiers of discovery. I am especially delighted to see the active involvement of young scientists and students, whose passion and creativity will be central to shaping India's scientific vision for 2047. I hope the deliberations and collaborations emerging from this platform will inspire breakthroughs that will impact both academia and society at large.

I extend my best wishes to all the participants and organizers for a successful and intellectually enriching symposium.

Warm regards,
(Amit Agrawal)

Message from
Shri Arpit Agrawal
Vice Chairperson,
JECRC University, Jaipur

It is an honor to welcome esteemed scientists and researchers to the Astronomical Society of India Symposium 003 – "Cosmic Vision 2047: Solar and Planetary Dynamics through Observations and AI/ML."

This gathering comes at a defining moment. As India moves towards its centenary of independence in 2047, our nation has already marked its place among global leaders in space science—through the triumph of Chandrayaan-3, the pioneering Aditya-L1 mission, and the bold integration of AI/ML into frontier research. The theme of this symposium—merging high-resolution observations with advanced computational intelligence—perfectly reflects the future of discovery, where science and technology converge to decode the Sun, planetary dynamics, and the mysteries of space weather.

At JECRC University, we see this as more than an event—it is part of a larger journey. Our research ecosystem, interdisciplinary collaborations, and innovation-driven culture are dedicated to preparing scholars and institutions alike for India's Cosmic Vision 2047. Hosting this symposium is both a privilege and a responsibility, as it allows us to contribute to shaping the conversations and collaborations that will define the decades ahead.

I am confident that the ideas exchanged here will not only advance scientific understanding but also strengthen India's leadership in global astronomy. I extend my congratulations to the organizers and participants, and wish this symposium great success.

With best wishes ,
(Arpit Agrawal)

Message from
Prof. Victor Gambhir
President
JECRC University, Jaipur

Dear Participants,

It is my privilege to extend a warm welcome to each of you as we gather for ASI Symposium 003 — "Cosmic Vision 2047: Solar and Planetary Dynamics through Observations and AI/ML", hosted by JECRC University, Jaipur.

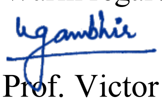
At JECRC University, our dedication to outcome-based education, project-driven learning, and research excellence forms the bedrock of our mission. With a strong emphasis on innovation-led research, our University has become a respected name nationally — due to our infrastructure, committed faculty, and culture of delivering on promises.

This symposium beautifully embodies that spirit. By merging observational breakthroughs with AI and ML innovations, and spotlighting recent achievements such as Aditya-L1 and other prominent space missions, it reflects the academic dynamism we strive for (as outlined in the symposium's overview).

I am especially heartened by the enthusiastic involvement of emerging scientists and early-career researchers. It is your curiosity and energy that will shape India's cosmic journey toward 2047.

On behalf of JECRC University, I extend my heartfelt gratitude to all contributors, organizers, and participants. May this symposium be a beacon of inspiration, collaboration, and discovery.

Warm regards,



Prof. Victor Gambhir

President,

JECRC University, Jaipur

Message from
Shri S. L. Agrawal
Registrar
JECRC University, Jaipur

Dear Participants,

It gives me great pleasure to welcome you all to ASI Symposium 003 — "Cosmic Vision 2047: Solar and Planetary Dynamics through Observations and AI/ML" , hosted by JECRC University, Jaipur.

As Registrar, I deeply value the efforts of all who have worked tirelessly to make this symposium a reality — from the academic leadership and organizing committee to the faculty, staff, and student volunteers. Such collective endeavours reflect the spirit of JECRC University, where collaboration and commitment drive academic excellence.

I am confident that the deliberations and discussions during this symposium will provide valuable insights, foster new collaborations, and inspire participants to contribute meaningfully to India's scientific vision for 2047.

I extend my best wishes for the success of the symposium and for a truly enriching experience for all participants.

Warm regards,

S. L. Agarwal
Registrar
JECRC University, Jaipur

भौतिक अनुसंधान प्रयोगशाला
(भारत सरकार, अंतरिक्ष विभाग की यूनिट)
नवरंगपुरा, अहमदाबाद - 380009, भारत

Physical Research Laboratory
(A Unit of Dept. of Space, Govt. of India)
Navrangpura, Ahmedabad 380009, India

प्रो. अनिल भारद्वाज, एफएनए, एफएएससी, एफएनएएससी
Prof. Anil Bhardwaj, FNA, FASc, FNASc
जे. सी. बोस नेशनल फेलो / **J. C. Bose National Fellow**
विशिष्ट प्राध्यापक / **Distinguished Professor**
निदेशक/Director

03 सितंबर, 2025

MESSAGE

It is a privilege to extend my warm greetings to all participants of the ASI Symposium (ASIS003) on "Cosmic Vision 2047: Solar and Planetary Dynamics through Observations and AI/ML", hosted at JECRC University, Jaipur, from 08–10 September 2025.

The theme, *Cosmic Vision 2047*, is far-sighted and inspirational. As India approaches its centenary of independence, it is essential for the space physics community to deliberate across diverse platforms on a long-term roadmap—one that leverages advanced observational facilities, powerful computational models, and the transformative potential of artificial intelligence and machine learning. Such a vision will not only deepen our scientific understanding of the Sun and heliophysics but also reinforce India's leadership in space sciences.

The Sun and planetary environments profoundly influence the near-Earth space environment, which in turn affects modern technological systems ranging from satellites and navigation to communication and power grids. Understanding space weather and developing reliable predictive capabilities are thus not only important scientific pursuits but also of great societal relevance.

The Physical Research Laboratory (PRL), founded by Dr. Vikram Sarabhai—the father of the Indian space program—has been at the forefront of space sciences for over seven decades. From pioneering studies in cosmic rays, planetary atmospheres, and astronomy, PRL has contributed significantly to India's space program. More recently, PRL has played key roles in national missions such as Chandrayaan-1, Chandrayaan-2, Chandrayaan-3, and the landmark Aditya-L1 mission, India's first dedicated solar observatory.

A jewel in PRL's crown is the Udaipur Solar Observatory (USO), established on 20 September 1975 under the visionary leadership of its founder, Dr. Arvind Bhatnagar. USO has emerged as one of the world's leading centers for high-quality ground-based solar observations and space weather research. As it soon enters its Golden Jubilee year, the observatory continues to play a pivotal role in unraveling the mysteries of the Sun and contributing to global space weather research, in close synergy with space-based missions like Aditya-L1.

On behalf of PRL, I sincerely thank the Scientific Organizing Committee, chaired by Prof. Bhuwan Joshi, for their initiative and dedicated efforts in conceptualizing and realizing this important symposium.

I wish the symposium great success and hope its deliberations inspire new ideas, collaborations, and discoveries that shape India's cosmic vision for 2047 and beyond.

With best wishes,

ABhardwaj
3/9/2025

प्रो. अनिल भारद्वाज
Prof. Anil Bhardwaj
निदेशक / Director

E-mail: abhardwaj@prl.res.in/bhardwaj_SPL@yahoo.com Phone:079-26314855

ASTRONOMICAL SOCIETY OF INDIA

(Regd. Office: Dept. of Astronomy, Osmania University, Hyderabad – 500 007)

Office Address: Indian Institute of Astrophysics, Koramangala, Bangalore 560034
Email: secretary@astron-soc.in

Prof. Devendra Kumar Ojha
President
Astronomical Society of India

Message from the President, Astronomical Society of India

It gives me immense pleasure to welcome all participants to the ASI Symposium (ASIS003) on "Cosmic Vision 2047: Solar and Planetary Dynamics through Observations and AI/ML", being held at JECRC University, Jaipur, from 08–10 September 2025.

This symposium brings together researchers, students, and educators from across India and abroad to deliberate on some of the most pressing scientific questions in solar and planetary physics. The timing of this meeting is especially significant—India has entered an exciting era of space-based solar and interplanetary exploration, highlighted by the Aditya-L1 mission, alongside our strong engagement in astronomy and planetary sciences, along with ground-based observatories.

The chosen theme, Cosmic Vision 2047, is forward-looking. As our nation approaches its centenary of independence, it is imperative that the astronomical community defines a long-term vision, one that harnesses cutting-edge observational facilities, computational models, and increasingly, the transformative power of artificial intelligence and machine learning. These approaches are reshaping how we analyze vast data streams from space- and ground-based instruments, enabling new discoveries and deeper insights into the dynamics of the Sun, planets, and their influence on space weather.

I am also delighted to note the inclusion of a dedicated astronomy outreach and education session, involving school students and teachers. Inspiring young minds and strengthening science education is central to ASI's mission, and such programs ensure that the next generation of scientists and citizens appreciate the importance of space research in shaping our future.

On behalf of the Astronomical Society of India, I thank the Scientific Organizing Committee, JECRC University, and all supporting institutions for their efforts in bringing this symposium to fruition. I am confident that the deliberations here will not only advance our understanding of solar and planetary dynamics but also sow the seeds of collaborations that will shape India's cosmic vision for decades to come.

I wish the symposium great success and fruitful discussions for all participants.

With warm regards,

DKOjha

Devendra Kumar Ojha
President, Astronomical Society of India

उदयपुर सौर वेधशाला
भौतिक अनुसंधान प्रयोगशाला
(अंतरिक्ष विभाग, भारत सरकार)
देवाली, बड़ी रोड, उदयपुर–313001

Udaipur Solar Observatory
Physical Research Laboratory
(Department of Space, Govt. of India)
Dewali, Badi Road, Udaipur-313001

प्लेटिनम जयंती 1947 75 2022 PLATINUM JUBILEE

Dr. Bhuwan Joshi
Professor

Message from the Chairman, Scientific Organizing Committee (SOC)

It gives me great pleasure to welcome you all to the ASI Symposium (ASIS003) on "Cosmic Vision 2047: Solar and Planetary Dynamics through Observations and AI/ML", being held at JECRC University, Jaipur, from 8–10 September 2025.

This symposium has been designed to foster vibrant scientific exchange across all levels of the community. We are delighted to host a wide spectrum of invited talks, ranging from eminent senior colleagues to mid-career researchers, as well as enthusiastic young scientists, postdoctoral fellows, and students. A notable feature of this meeting is the active participation from the university sector, which enriches the breadth and diversity of the discussions. In addition to the main sessions, the symposium features dedicated outreach components, including parallel sessions for teachers, educators, and students, designed to foster capacity-building in space sciences.

We are also pleased to note the strong pan-India representation, with participants from diverse institutions across the country, and a healthy participation of women scientists. Issues of gender balance in science remain important, and meetings like this play a role in promoting inclusivity and equal opportunities.

I take this opportunity to sincerely thank the SOC members for their tireless efforts in shaping this symposium. I am equally grateful to our colleagues at JECRC University for their generous support in local organization and logistics.

We deeply acknowledge the Astronomical Society of India (ASI) for approving our proposal and providing core support. Our sincere thanks also go to ANRF-DST and ISRO for additional funding, which has enabled the participation of many students and early-career researchers.

Finally, I extend heartfelt gratitude to all our invited speakers, participants, and volunteers, whose contributions and enthusiasm are the true driving force of this meeting.

I wish you all a stimulating and fruitful symposium, and I look forward to the exciting discussions and collaborations that will emerge from it.

With best regards,

Bhuwan Joshi 04/09/2025

Bhuwan Joshi
Chairman, Scientific Organizing Committee

दूरभाष / Phone : +91 294-2457201 (Office), 91 294-2457171/172 (Island), फैक्स / Fax : + 91 294-2457202, वेबसाईट / Website - https://www.PRL.RES.IN

Message from the SOC Co-Chairs


Dear Colleagues,

It is our great pleasure to welcome you to the ASI Symposium 003 – "Cosmic Vision 2047: Solar and Planetary Dynamics through Observations and AI/ML," hosted at JECRC University, Jaipur.

This symposium brings together leading experts and young researchers to explore the Sun, planetary dynamics, and space weather through both observational breakthroughs and AI/ML innovations. Over the next three days, our sessions will highlight advances from missions such as Aditya-L1 and Chandrayaan-3, alongside new theoretical and computational approaches.

We are especially encouraged by the enthusiastic participation of students and early-career scientists, whose fresh perspectives will shape the future of our field. We hope the discussions here spark new ideas, collaborations, and inspiration as we look toward India's cosmic vision for 2047.

We thank all contributors for making this symposium possible and wish you an engaging and rewarding experience in the Pink City of Jaipur.

Warm regards,

Prof. Abhishekh Kumar Srivastava
SOC Co-Chair

Dr. Chandan Joshi
SOC Co-Chair

Message from the Head, Department of Physics

Dear Participants,

On behalf of the Department of Physics, School of Sciences, JECRC University , I am delighted to welcome you to *ASI Symposium 003— "Cosmic Vision 2047: Solar and Planetary Dynamics through Observations and AI/ML".Hosting this prestigious event in collaboration with the Astronomical Society of India is a matter of great pride for our department, as it brings together eminent scientists, researchers, and young scholars from across the country. The Department of Physics has always strived to blend academic rigor with research excellence , with faculty expertise spanning Solar Astronomy, Material Science, Plasma Physics, and Nuclear Physics. With the establishment of our R&D Material Science Lab , we continue to nurture scientific curiosity and provide students with meaningful experiential learning opportunities, in line with the vision of NEP 2020.

I am especially encouraged by the active involvement of young researchers and students in this symposium, as their participation reflects our mission to foster an environment of inquiry, innovation, and collaboration . I am confident that the deliberations during this event will broaden perspectives and inspire significant contributions to India's scientific aspirations for 2047. I extend my sincere gratitude to the University leadership, organizing committee, speakers, and participants whose dedicated efforts and enthusiasm have made this symposium possible. Wishing everyone a fruitful, engaging, and intellectually enriching experience .

Warm regards,

Prof. Pranav Saxena

Head of the Department of Physics

JECRC University, Jaipu

Message from the Director, Centre of Research & Environment Sustainability, JECRC University

Dear Colleagues and Participants,

I am delighted to welcome you to ASI Symposium 003, "Cosmic Vision 2047: Solar and Planetary Dynamics through Observations and AI/ML," which will be held from September 8 to 10, 2025. This event promises to be a landmark in our collective journey toward understanding the cosmos. We are confident that the energy, depth of discussion, and innovative ideas shared here will inspire all of us.

Understanding solar and planetary dynamics is key to advancing astrophysics and preparing for space weather events that impact our technology, environment, and long-term sustainability. This work aligns perfectly with our Centre's mission to tackle global challenges through innovative, sustainable, and collaborative research.

I am especially inspired by the young scholars here. Your passion and creativity are exactly what we need to find new solutions and perspectives in this evolving field. I'm confident this symposium will spark fruitful discussions, meaningful collaborations, and innovative pathways as we work toward India's scientific vision for 2047.

I wish the symposium every success and hope you all find the experience inspiring and truly memorable

Warm regards,

Prof. Hardik Pathak
Director, Centre of Research and Environment Sustainability
JECRC University, Jaipur

ABOUT THE UNIVERSITY

JECRC University is a leading private institution located in Jaipur, Rajasthan, established in 2012. Recognized by the University Grants Commission (UGC) and holding the prestigious 12(B) status, the university is eligible to receive central government grants for research and development, underscoring its commitment to academic excellence and innovation.

The university offers a wide range of undergraduate, postgraduate, and doctoral programs in fields such as engineering, management, sciences, law, humanities, and design. With a strong emphasis on practical learning, JECRC University promotes hands-on projects, internships, and industry collaborations to equip students with real-world skills. JECRC University has a robust research ecosystem with dedicated centers focusing on emerging technologies like artificial intelligence, data science, robotics, and renewable energy.

The university boasts state-of-the-art infrastructure, including modern laboratories, well-equipped libraries, and digital learning resources to support academic growth. The university's vibrant campus life encourages student participation through cultural events, sports, and various clubs, ensuring holistic development. Its strong ties with industry leaders facilitate excellent placement opportunities for students. We have multiple seminar hall and conference rooms with maximum capacity of 600 and minimum capacity of 90.

ABOUT THE SYMPOSIUM

The symposium "Cosmic Vision 2047: Solar and Planetary Dynamics through Observations and AI/ML", organized by JECRC University in collaboration with the Astronomical Society of India (ASI), provides a focused platform to discuss recent advancements in solar physics, planetary science, and space weather prediction. With the advent of missions like Aditya-L1, Mangalyaan, and Chandrayaan-3, alongside international collaborations, the symposium highlights India's growing role in exploring the Sun's influence on planetary systems.

A special emphasis is placed on the transformative role of Artificial Intelligence and Machine Learning (AI/ML) in analyzing vast solar and planetary datasets, improving solar storm predictions, and enhancing planetary surface mapping. By integrating observational data, theoretical models, and computational tools, the event seeks to address critical challenges in understanding solar variability, planetary environments, and their technological implications.

Bringing together scientists, researchers, and early-career scholars, the symposium fosters interdisciplinary collaboration in line with India's centenary scientific goals for 2047. It serves not only as a platform for knowledge sharing but also as an inspiration for the next generation of researchers in the fields of solar and planetary dynamics.

Thrust Areas

1. Dynamical Plasma Processes in the Solar Atmosphere at Diverse Scales
2. Solar Eruptions: Causes and Consequences
3. Planetary Space Weather
4. Ground- and Space-Based Observations of the Sun and Solar Phenomena
5. AI/ML Applications in Solar and Space Physics
6. Astronomy Public Outreach Activities

About the Centre for Research in Environmental Sustainability (CRES), JECRC University, Jaipur

The JECRC Center for Research in Environmental Sustainability (CRES) is dedicated to nurturing sustainable practices and addressing global challenges through interdisciplinary research, educational initiatives, and community outreach . With a vision to foster a sustainable future, the Center seeks to inspire and empower individuals and communities to embrace environmentally conscious practices. Its mission emphasizes the development of eco-friendly, cost-effective, and socially acceptable technologies, while also raising awareness about the equitable use of natural resources and the conservation of biodiversity.

The Center functions as a dynamic platform for research advancement, global collaboration, and knowledge dissemination . It actively promotes joint research projects, fosters industry-academic partnerships, and encourages interdisciplinary approaches to address pressing sustainability issues. Through workshops, seminars, conferences, and panel discussions, CRES provides opportunities for intellectual exchange and the sharing of best practices. The Center also plays a key role in publishing research outcomes, networking with institutions globally, and facilitating student and faculty engagement with Sustainable Development Goals (SDGs).

In essence, CRES stands as a hub for innovation and collaboration, working toward the creation of eco-friendly technologies and sustainable solutions . By bridging academia, industry, and community efforts, the Center aspires to contribute meaningfully to environmental conservation and sustainable development on both national and international scales.

ABOUT THE PHYSICS DEPARTMENT

The Department of Physics was established in 2012 with the inception of JECRC University. Since its foundation, the department has been consistently contributing to both academic excellence and research innovation within the School of Sciences. It is supported by a team of highly qualified faculty members with diverse research specializations, offering a vibrant Ph.D. program in areas such as Solar Astronomy, Material Science, Composite Materials, Thin Films, Plasma Physics, Hydrogen Energy, Nuclear Physics, and Microwave Electronics. The department boasts a strong academic foundation, with faculty members holding degrees from nationally and internationally reputed institutions and possessing extensive teaching and research experience.

A significant milestone is the establishment of the R&D Material Science Lab, equipped with state-of-the-art instruments for the fabrication and characterization of advanced materials. This facility provides students and researchers with hands-on experience, fostering experiential learning and enhancing global competence. Currently, the department offers Ph.D., M.Sc. (Physics), and B.Sc. (Hons.) programs, with specializations aligned to emerging fields. Students gain practical exposure through collaborations and project work at esteemed organizations such as ISRO, DAE, Solar Observatories, State Forensic Science Laboratories, the Ministry of Earth Sciences, and other premier research institutes.

ORGANIZERS

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Shri Amit Agrawal, Vice-Chairperson, JECRC University, Jaipur, Rajasthan

Shri Arpit Agrawal, Vice-Chairperson, JECRC University, Jaipur, Rajasthan

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Convener: Dr. Nidhi Bansal

Member: Dr. Renu Sharma

2. Inaugural and validity committee (Anchoring: Dr. Ruchita Burman)

Convener: Prof. Ekta Menghani and Dr. Poonam Hariyani

Members: Dr. Anjali Yadav

Dr. Beena Bundela

Ms. Cheena Kaushal

3. Memento/ Certificate distribution committee

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Members: Dr. Anjali Yadav

Ms. Cheena Kaushal

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Dr. Ravi Kant Rahi

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Convener: Shri C. P. Beniwal

Members: Shri Ramsharan Gupta

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Prof. Sonu Pareek

11. Media Person University: Dr Nikita Batra

12. Social Media: Mr Karthik Saini

13. Photography: Ms. Aishwarya Phagiwala

14. Mess arrangement: Shri Nirmal Jain

15. Seminar hall fifth floor Nyay Bhawan and Seminar Hall Vikram Sarabhai Bhavan arrangements: Mr Nitin Gupta

16. Electricity and the power backup: Shri Sher Singh

Astronomical Society of India Symposium (ASIS003) Cosmic Vision 2047: Solar and Planetary Dynamics through Observations and AI/ML 08 -10 September 2025

Day 1 (8.9.25)

IT/ CT	Speaker Name	Title
IT	Nat Goplaswamy, NASA/GSFC	Observing the Low Frequency Radio Sky from the Moon Under NASA's Commercial Lunar Payload Services Program
IT	SantoshVadawale, PRL	Advancing Solar X-ray Spectroscopy: From 'Sun-as-a-star' to High Cadence Imaging Spectroscopy
IT	KuldeepVerma, IIT-BHU	Internal Structure of the Sun and Solar-like Stars Using Seismology
CT	Sandeep K. Dubey, USO-PRL	Investigating Bidirectional Flows in a Quiescent Prominence Using MAST Ca II 8542 Å Line Scan Observations
CT	Jithu J Athalathil, IIT Indore	Investigating Nonlinear Quenching Effects on Polar Field Buildup Using Physics-Informed Neural Networks
CT	DibyaKirti Mishra, ARIES	Exploring Historical Solar Activity: Neural Network Detection of Plages in Suncharts
IT	Jayant Joshi, IIA	Quiet-Sun Ellerman Bombs and Their Impact on the Upper Solar Atmosphere
IT	Pradeep Kayshap, VIT Bhopal University	Solar Jets: Physical Properties and Triggering Processes
IT	Sanjay Kumar, Patna University	Exploring the Source Region Dynamics of Coronal Transients Utilizing Data-Constrained MHD Simulations
CT	MirabbosMirkamalov, Samarkand State University	Probing the Role of Pre-eruptive Magnetic Fields and Electric Currents in

		the HXR Footpoint Asymmetry During Flares
CT	Akash Bairagi, IIT-BHU	Numerical Modelling of the Magnetic Reconnection in the Chromospheric Current Sheets
CT	Srinjana Routh, ARIES	Radio Insights on Large-scale Chromospheric Flows: A Study Using Nobeyama 17 Ghz Data
CT	Hema Kharayat, MLKPG College, Balrampur	Solar Chromospheric Differential Rotation Across Latitudes Using Ca-K Line Features from Kodaikanal Observatory
CT	Amit Chaturvedi, USO-PRL	On Spatial Distribution of Umbral Dots
IT	Lakshmi PradeepChitta, MPS	Structure of the Photosphere and the Corona — New Insights with Solar Orbiter
IT	Sanjiv K. Tiwari, LMSAL & BAERI	Fine-Scale Heating Events in the Solar Atmosphere Revealed by Recent High-Resolution Telescopes

Day 2 (9.9.25)

IT	Jagdev Singh, IIA	Coronal Spectroscopy: Past, Present, and Future
IT	NPS Mithun, PRL	An X-ray Perspective on Solar Flares
IT	Arun Kumar Awasthi, Polish Academy of Sciences	Probing the Physics of Radiation and Particles Emitted During Energetically Rich Solar Flares
CT	GarimaKarki, Kumaun University	Spectroscopic Evidence of Magnetic Reconnection Between a Solar Jet and a Filament Channel
CT	Devesh Sharma, IIT Indore	Modelling the Wave Dynamics of Solar Atmosphere to Study Coronal Heating

CT	Yogesh Kumar Maurya, USO-PRL	Exploring Solar Jet Onset, Evolution, and Their Associated Magnetic Topology Through a Data-constrained Magnetohydrodynamics Evolution of Active Region Ar13141
IT	Dibyendu Chakrabarty, PRL	ASPEX on-board Aditya-L1: Heliospheric, Solar Wind and Space Weather Science Potential
IT	Kirit D. Makwana, IIT Hyderabad	Turbulence and Intermittent Structures at Kinetic Scales in Solar Wind
CT	Anjali Agarwal, IIA	Examining the Mesoscale Inhomogeneity in a CME Substructure Near 1 AU
CT	Kishor Kumbhar, University of Mumbai	Kinetic Instabilities Constraining Proton Temperature Anisotropy in Corotating Interaction Regions at 1 AU
CT	BijoyDalal, PRL	Energetic (< 2 MeV) Ion Measurements from ASPEX-STEPS During the Earth-bound Phases of Aditya-L1
IT	Vipin K. Yadav, SPL, VSSC	Interplanetary Magnetic Field (IMF) Fluctuations During Solar Transient Events: Observations by MAG Payload onboard Aditya-L1 Spacecraf
IT	Ramesh Chandra, Kumaun University	Solar Filament Eruptions and Coronal Loop Dynamics
IT	NitinYadav, IIT Delhi	The Alfvénic Nature of Vortex Flows in the Solar Atmosphere
CT	Shakti Singh, NIT Delhi	Long-period Decayless Kink Oscillation Detected in Solar Coronal Loop
CT	Simrat Kaur, USO-PRL	Numerical Study of a B-class Flare Using the Using the XSM, GOES, HMI/SDO and AIA/SDO
CT	Mayank Rajput, NIT Rourkela	MUSER Imaging of Decimetric Radio Emission: Unveiling Its Link to Offlimb

		Prominence Eruption Rather Than the on-disk Solar Flare
IT	Vaibhav Pant, ARIES	High-Resolution Observations of Transverse Waves in the Solar Corona: From Loops to Plumes
IT	Anshu Kumari, USO-PRL	Source Sizes of Type II Radio Bursts
CT	Sripan Mondal, IIT-	BHU Mutual Association of Waves and Reconnection in the Solar Corona
CT	Vishwa Vijay Singh, USO-PRL	Exploring Flare Onset and Flare–CME Coupling: Multi-Instrument Observations of a Superfast CME Associated with an X3.3-Class Flare from HEL1OS/Aditya-L1, Udaipur LWA, and AIA/SDO
CT	Bablu Mandal, ARIES	A Spatio-Temporal Study of a Steady Supersonic Downflow in AR 12135 Using IRIS data
CT	Shilpa Patra, NIT Delhi	Flare Ribbons and Reconnection Dynamics in an M3.4 Solar Flare from NOAA AR 13668: Evidence of J-Shaped Flare Ribbons
CT	P. R. Singh, University of Allahabad	Relation Between the Ca II (H & K) Lines and Mg II Lines During Solar Cycle 24

Day 3 (10.9.25)

IT	Anil Raghav, University of Mumbai	Multiscale Features Inside ICMEs
IT	BhargavaVaidya, IIT Indore	Fostering Synergy Between Magnetohydrodynamic Space Weather Modeling and in-situ Space-based Data
IT	Susanta Kumar Bisoi, NIT Rourkela	Inner-heliospheric Signatures of Steadily Declining Solar Magnetic Fields and Their Possible Implications

CT	Subhash C. Kaushik, Govt. PG Autonomous College, Datia	Space Weather During Extremely Disturbed Geomagnetic Field and CR Variations
CT	Sreejith S. Nair, NIT Warangal	Simulating the Eruptive Flux Ropes Using Data-driven Magnetofrictional Approach
CT	Akshita Bhardwaj, IIT Roorkee	Self-Similar Analysis of Shock Waves in Jupiter's Magnetosphere
IT	Wageesh Mishra, IIA Bangalore	Role of Thermal States and Interactions of CMEs in Modulating Their Geoeffectiveness
IT	Prithish Halder, University of Nebraska, Lincoln	Physics-based Flare Forecasting: Role of Winding Flux and Persistent PILS Evolution During Precursor Phase of the Intense Solar Flares
CT	Aakash Gupta, PRL	Multi-directional Investigations on Quiet-time Suprathermal Ions in the Interplanetary Medium Measured by ASPEX-STEPS on-board Aditya-l1
CT	Saket Kumar, AKS University	Characterizing Severe Geomagnetic Storms and Their Magnetospheric Drivers in Solar Cycle 23 & 24
CT	AswinAmirtha Raj, Arul Anandar College, Madurai	Geo-effective CME from Weak Magnetic Patches: A Case Study
CT	Yimnasangla, IIT Mandi	Comparative Analyses of Soliton Signatures in Geomagnetic Storm Phases During Solar Cycles 24–25 Using Cluster II Data
CT	ShivamParashar, PRL	Insights Into SolarTransients and Ambient Solar Wind from One Year of ASPEX/SWIS Operations
IT	Shibu K. Mathew, USO-PRL	Multi-Application Solar Telescope – Instruments and Capabilities

IT	V. Muthu Priyal, IIA	Diagnostic Study of Solar Coronal Dynamics Using VELC 5303 Å Spectroscopic Observations
CT	Prakhar Singh, ARIES	Confined vs. Eruptive Solar Flares: A Thermal and Compositional Diagnostic Study with Aditya-L1/SoLEXS
CT	Hasil Dixit, USO-PRL	Characterizing Small-scale Transient ChromosphericBrightenings Using Data from MAST and SDO
CT	Rohan Bose, ARIES	Multiwavelength Study of Solar Polar Coronal Hole Jets
IT	GeetaVichare, IIG	Low-latitude Aurora Observations from the Indian Region
IT	P K Manoharan, NASA/GSFC	Real-time Identification of Space Weather Important Events

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<tr><td colspan="2">Astronomical Society of India Symposium (ASIS003)
Cosmic Vision 2047:
Solar and Planetary Dynamics through Observations and AI/ML
08-10 September 2025</td></tr>
<tr><td colspan="2">**Day – 1 [08 September 2025]**</td></tr>
<tr><td>Registration</td><td>8:00 – 8:45 AM</td></tr>
<tr><td colspan="2">**Inaugural Session**
8:40 – 10:00</td></tr>
<tr><td>09:00 – 10:00</td><td>• Lightening the Lamp by the Chief Guest and Other Dignitaries (5 Min)
• Welcome Address by the JECRC University Representative (5 Min)
• Keynote Address by the Chief Guest (20 min)
• Overview of the Scientific Program of the Symposium – delivered by Chair, SOC (10 min)
• Address by the Vice-Chancellor, JECRC University (5 Min)
• Message by the President, ASI (5 Min)
• Vote of Thanks by the Co-Chair, SOC (5 min)
• National Anthem</td></tr>
<tr><td colspan="2">**10:00 – 11:00 | Group Photo & High Tea**</td></tr>
<tr><td colspan="2">**Opening Session**
The Sun and Space: Opening New Horizons
Chair: Dibyendu Chakrabarty</td></tr>
<tr><td>11:00 – 11:30
Invited Talk</td><td>**Nat Goplaswamy, NASA/GSFC**
Observing the Low Frequency Radio Sky from the Moon Under NASA's Commercial Lunar Payload Services Program</td></tr>
<tr><td>11:30 – 12:00
Invited Talk</td><td>**Santosh Vadawale, PRL**
Advancing Solar X-ray Spectroscopy: From 'Sun-as-a-star' to High Cadence Imaging Spectroscopy</td></tr>
<tr><td colspan="2">**Technical Session 1**
Magnetic Genesis and Photosphere-Chromosphere Dynamics
Chair: Jagdev Singh</td></tr>
<tr><td>12:00 – 12:30
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Internal Structure of the Sun and Solar-like Stars Using Seismology</td></tr>
<tr><td>12:30 – 13:10
Contributory Talks
(12 minutes each)</td><td>**Sandeep K. Dubey, USO-PRL**
Investigating Bidirectional Flows in a Quiescent Prominence Using MAST Ca II 8542 Å Line Scan Observations

Jithu J Athalathil, IIT Indore
Investigating Nonlinear Quenching Effects on Polar Field Buildup Using Physics-Informed Neural Networks

Dibya Kirti Mishra, ARIES
Exploring Historical Solar Activity: Neural Network Detection of Plages in Suncharts</td></tr>
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13:10 – 13:30 Invited Talk (Online)	**Jayant Joshi, IIA** Quiet-Sun Ellerman Bombs and Their Impact on the Upper Solar Atmosphere
13:30 – 14:30 | Lunch	
Technical Session 1 (Contd.) **Magnetic Genesis and Photosphere-Chromosphere Dynamics** **Chair:** Santosh Vadawale	
14:30 – 14:50 Invited Talk	**Pradeep Kayshap, VIT Bhopal University** Solar Jets: Physical Properties and Triggering Processes
14:50 – 15:10 Invited Talk	**Sanjay Kumar, Patna University** Exploring the Source Region Dynamics of Coronal Transients Utilizing Data-Constrained MHD Simulations
15:10 – 16:00 Contributory Talks (12 minutes each)	**Mirabbos Mirkamalov, Samarkand State University** Probing the Role of Pre-eruptive Magnetic Fields and Electric Currents in the HXR Footpoint Asymmetry During Flares **Akash Bairagi, IIT-BHU** Numerical Modelling of the Magnetic Reconnection in the Chromospheric Current Sheets **Srinjana Routh, ARIES** Radio Insights on Large-scale Chromospheric Flows: A Study Using Nobeyama 17 Ghz Data **Hema Kharayat, MLKPG College, Balrampur** Solar Chromospheric Differential Rotation Across Latitudes Using Ca-K Line Features from Kodaikanal Observatory
16:00 – 16:45 | Tea & Poster Session	
Technical Session 1 (Contd.) **Magnetic Genesis and Photosphere-Chromosphere Dynamics** **Chair:** Kirit D. Makwana	
16:45 – 16:57 Contributory Talk	**Amit Chaturvedi, USO-PRL** On Spatial Distribution of Umbral Dots
17:00 – 17:30 Invited Talk (Online)	**Lakshmi Pradeep Chitta, MPS** Structure of the Photosphere and the Corona — New Insights with Solar Orbiter
17:30 – 18:00 Invited Talk (Online)	**Sanjiv K. Tiwari, LMSAL & BAERI** Fine-Scale Heating Events in the Solar Atmosphere Revealed by Recent High-Resolution Telescopes

Day – 2 [09 September 2025]	
Technical Session 2 **Solar Corona and Transient Phenomena** **Chair:** Bhargav Vaidya	
09:00 – 9:30	**Jagdev Singh, IIA**

Invited Talk	Coronal Spectroscopy: Past, Present, and Future
09:30 – 09:50 Invited Talk	**NPS Mithun, PRL** An X-ray Perspective on Solar Flares
09:50 – 10:10 Invited Talk	**Arun Kumar Awasthi, Polish Academy of Sciences** Probing the Physics of Radiation and Particles Emitted During Energetically Rich Solar Flares
10:10 – 10:50 Contributory Talks (12 minutes each)	**Garima Karki, Kumaun University** Spectroscopic Evidence of Magnetic Reconnection Between a Solar Jet and a Filament Channel **Devesh Sharma, IIT Indore** Modelling the Wave Dynamics of Solar Atmosphere to Study Coronal Heating **Yogesh Kumar Maurya, USO-PRL** Exploring Solar Jet Onset, Evolution, and Their Associated Magnetic Topology Through a Data-constrained Magnetohydrodynamics Evolution of Active Region Ar13141
10:50 – 11:30 | Tea and Poster Session	
Technical Session 3 **Origin of Space Weather** **Chair:** Nitin Yadav	
11:30 – 12:00 Invited Talk	**Dibyendu Chakrabarty, PRL** ASPEX on-board Aditya-L1: Heliospheric, Solar Wind and Space Weather Science Potential
12:00 – 12:20 Invited Talk	**Kirit D. Makwana, IIT Hyderabad** Turbulence and Intermittent Structures at Kinetic Scales in Solar Wind
12:20 – 13:10 Contributory Talks (12 minutes each)	**Anjali Agarwal, IIA** Examining the Mesoscale Inhomogeneity in a CME Substructure Near 1 AU **Kushagra Upadhyay, USO-PRL** Solar Radio Observations at USO-PRL: Programs and Initiatives for Solar Sciences and Space Weather Monitoring **Kishor Kumbhar, University of Mumbai** Kinetic Instabilities Constraining Proton Temperature Anisotropy in Corotating Interaction Regions at 1 AU **Bijoy Dalal, PRL** Energetic (< 2 MeV) Ion Measurements from ASPEX-STEPS During the Earth-bound Phases of Aditya-L1
13:10 – 13:30 Invited Talk	**Vipin K. Yadav, SPL, VSSC** Interplanetary Magnetic Field (IMF) Fluctuations During Solar Transient Events: Observations by MAG Payload onboard Aditya-L1 Spacecraft
13:30 – 14:30 | Lunch	
Technical Session 4	

Coupling and Dynamics of Solar Atmosphere **Chair:** Abhishekh K. Srivastava	
14:30 – 15:00 Invited Talk	**Ramesh Chandra, Kumaun University** Solar Filament Eruptions and Coronal Loop Dynamics
15:00 – 15:20 Invited Talk	**Nitin Yadav, IIT Delhi** The Alfvénic Nature of Vortex Flows in the Solar Atmosphere
15:20 – 16:00 Contributory Talks (12 minutes each)	**Shakti Singh, NIT Delhi** Long-period Decayless Kink Oscillation Detected in Solar Coronal Loop **Simrat Kaur, USO-PRL** Numerical Study of a B-class Flare Using the Using the XSM, GOES, HMI/SDO and AIA/SDO **Mayank Rajput, NIT Rourkela** MUSER Imaging of Decimetric Radio Emission: Unveiling Its Link to Off-limb Prominence Eruption Rather Than the on-disk Solar Flare
16:00 – 16:30 | Tea & Poster Session	
Technical Session 4 (Contd.) **Coupling and Dynamics of Solar Atmosphere** **Chair:** Shibu K. Mathew	
16:30 – 17:00 Invited Talk	**Vaibhav Pant, ARIES** High-Resolution Observations of Transverse Waves in the Solar Corona: From Loops to Plumes
17:00 – 17:20 Invited Talk	**Anshu Kumari, USO-PRL** Source Sizes of Type II Radio Bursts
17:20 – 18:20 Contributory Talks (12 minutes each)	**Sripan Mondal, IIT-BHU** Mutual Association of Waves and Reconnection in the Solar Corona **Vishwa Vijay Singh, USO-PRL** Exploring Flare Onset and Flare–CME Coupling: Multi-Instrument Observations of a Superfast CME Associated with an X3.3-Class Flare from HEL1OS/Aditya-L1, Udaipur LWA, and AIA/SDO **Bablu Mandal, ARIES** A Spatio-Temporal Study of a Steady Supersonic Downflow in AR 12135 Using IRIS data **Shilpa Patra, NIT Delhi** Flare Ribbons and Reconnection Dynamics in an M3.4 Solar Flare from NOAA AR 13668: Evidence of J-Shaped Flare Ribbons **P. R. Singh, University of Allahabad** Relation Between the Ca II (H & K) Lines and Mg II Lines During Solar Cycle 24
18:30 – 19:30 | Cultural Program @ JECRC University	
19:30 – 21:30 | Conference Dinner @ JECRC University	

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Geoeffectiveness and Comparative Planetary Space Weather
Chair: Nat Gopalswamy</td></tr>
<tr><td>09:00 – 09:30
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Multiscale Features Inside ICMEs</td></tr>
<tr><td>09:30 – 10:00
Invited Talk</td><td>Bhargav Vaidya, IIT Indore
Fostering Synergy Between Magnetohydrodynamic Space Weather Modeling and in-situ Space-based Data</td></tr>
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<tr><td>10:20 – 11:00
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(12 minutes each)</td><td>Subhash C. Kaushik, Govt. PG Autonomous College, Datia
Space Weather During Extremely Disturbed Geomagnetic Field and CR Variations

Sreejith S. Nair, NIT Warangal
Simulating the Eruptive Flux Ropes Using Data-driven Magnetofrictional Approach

Akshita Bhardwaj, IIT Roorkee
Self-Similar Analysis of Shock Waves in Jupiter’s Magnetosphere</td></tr>
<tr><td colspan="2">11:00 – 11:30 Tea and Poster Viewing</td></tr>
<tr><td colspan="2">Technical Session 5 (Contd.)
Geoeffectiveness and Comparative Planetary Space Weather
Chair: Anil Raghav</td></tr>
<tr><td>11:30 – 12:00
Invited Talk</td><td>Wageesh Mishra, IIA Bangalore
Role of Thermal States and Interactions of CMEs in Modulating Their Geoeffectiveness</td></tr>
<tr><td>12:00 – 12:20
Invited Talk</td><td>Prithish Halder, University of Nebraska, Lincoln
Physics-based Flare Forecasting: Role of Winding Flux and Persistent PILS Evolution During Precursor Phase of the Intense Solar Flares</td></tr>
<tr><td>12:20 – 13:20
Contributory Talks
(12 minutes each)</td><td>Aakash Gupta, PRL
Multi-directional Investigations on Quiet-time Suprathermal Ions in the Interplanetary Medium Measured by ASPEX-STEPS on-board Aditya-l1

Saket Kumar, APS University
Characterizing Severe Geomagnetic Storms and Their Magnetospheric Drivers in Solar Cycle 23 & 24

Aswin Amirtha Raj, Arul Anandar College, Madurai
Geo-effective CME from Weak Magnetic Patches: A Case Study

Yimnasangla, IIT Mandi
Comparative Analyses of Soliton Signatures in Geomagnetic Storm Phases During Solar Cycles 24–25 Using Cluster II Data</td></tr>
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	Shivam Parashar, PRL Insights Into Solar Transients and Ambient Solar Wind from One Year of ASPEX/SWIS Operations
13:30 – 14:30 | Lunch	
Technical Session 6 **Contemporary Observing Programs and New Insights** **Chair:** Satheesh Thampi	
14:30 – 15:00 Invited Talk	**Shibu K. Mathew, USO-PRL** Multi-Application Solar Telescope – Instruments and Capabilities
15:00 – 15:20 Invited Talk	**V. MuthuPriyal, IIA** Diagnostic Study of Solar Coronal Dynamics Using VELC 5303 Å Spectroscopic Observations
15:20 – 16:00 Contributory Talks (12 minutes each)	**Prakhar Singh, ARIES** Confined vs. Eruptive Solar Flares: A Thermal and Compositional Diagnostic Study with Aditya-L1/SoLEXS **Hasil Dixit, USO-PRL** Characterizing Small-scale Transient Chromospheric Brightenings Using Data from MAST and SDO **Rohan Bose, ARIES** Multiwavelength Study of Solar Polar Coronal Hole Jets
16:00 – 16:30 |Tea	
Technical Session 7 **Interplanetary Medium and Sun-Earth Interactions** **Chair:** Vipin Yadav	
16:30 – 17:00 Invited Talk	**Geeta Vichare, IIG** Low-latitude Aurora Observations from the Indian Region
17:00 – 17:30 Invited Talk (Online)	**P K Manoharan, NASA/GSFC** Real-time Identification of Space Weather Important Events
17:30 – 18:00 | Concluding Session	

Observing the Low Frequency Radio Sky from the Moon under NASA's Commercial Lunar Payload Services Program

Nat Gopalswamy
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ABSTRACT

NASA's Commercial Lunar Payload Services (CLPS) program is a collaboration between NASA science teams and commercial aerospace companies to deliver science payloads to the Moon. There are many efforts to establish future large radio observatories on the Moon and the CLPS program allows developing pathways towards such a goal. The first NASA-funded radio telescope on the Moon was launched onboard Intuitive Machine's Odysseus lander and was deployed on the Moon on 2024 February 22. The telescope consisted of four monopole antennas designed to study the low-frequency radio sky and the local lunar plasma environment. The radio instrument is named ROLSES (Radio-wave Observations of the Lunar Photo-electron Sheath) and was one of the first payloads developed under CLPS. Odysseus had a "hard" soft-landing, breaking one of its legs, and was tipped over onto the lunar surface at an angle of ≈30◦. Nevertheless, we were able to deploy ROLSES antennas and were able to obtain some data. One of the four monopole antennas deployed unexpectedly enroute due to excessive solar flux falling on the deployment mechanism and overheating it. We were able to operate the telescope both enroute and on the surface obtaining data only for tens of minutes. With this data, it was possible to observe signals from ground transmitters above the ionospheric cutoff. I present these observations and future plans for the improved version of the ROLSES instrument to be flown on Firefly Aerospace's Blue Ghost lander.

Advancing Solar X -ray Spectroscopy: From 'Sun -as-a-star' to high cadence imaging spectroscopy

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Physical Research Laboratory, Ahmedabad
Email: santoshv@prl.res.in

ABSTRACT

The Solar X-ray Monitor (XSM) onboard the Chandrayaan-2 orbiter has been a key instrument in observing the Sun from lunar orbit, providing integrated disk measurements of solar X-ray spectra over the energy range of 1–15 keV. With its high temporal cadence and exceptional energy resolution, XSM has been actively capturing a wide array of solar phenomena for the past six years. These observations span a variety of phenomena ranging from the absolutely quiet Sun to sub-A class microflares to large M class flares, and have significantly contributed in enhancing our understanding of solar flares.

While XSM's disk-integrated measurements provide valuable insights, it also highlights the need for more detailed, high-cadence imaging spectroscopy, particularly during the presence of multiple active regions. However, obtaining such observations is a daunting challenge, both technically and operationally. The complexity arises from the combination of X-ray imaging with the demand of a large dynamic range and large data volume. In this talk, I will discuss a few possibilities of realising such a telephone and will highlight how AI/ML techniques can be utilised to address the operational challenges.

Internal Structure of the Sun and Solar-like Stars Using Seismology

Kuldeep Verma

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Email: kuldeep.phy@itbhu.ac.in

ABSTRACT

Seismology has revolutionized our understanding of the internal structures of the Sun and solar-like stars by allowing us to peer beneath their surfaces with unprecedented precision. Through the analysis of resonant oscillation modes, helioseismology has enabled detailed mapping of the solar interior, revealing the radial profiles of sound speed, internal rotation, and the location of the base of the convective envelope. With the advent of high-precision photometric space missions such as Kepler and TESS, asteroseismology has extended this capability to thousands of solar-like stars across the Galaxy, providing valuable constraints on fundamental stellar properties such as mass, radius, age, and surface helium abundance. In this talk, I will present recent advances in our understanding of stellar interiors, with a focus on how seismology constrains key physical processes such as convective overshooting, internal rotation, and magnetic fields. Moreover, I will discuss how combining a stereo seismic diagnostics with either conventional forward modelling or machine learning techniques can help us infer fundamental stellar properties. These developments not only refine our models of solar and stellar evolution but also have broader implications for Galactic archaeology and exoplanetary science.

Investigating Bidirectional Flows in a Quiescent Prominence Using MAST Ca II 8542 E Line Scan Observations

Sandeep K. Dubey[1, 2], Andrew Hillier[3] and Shibu K. Mathew[1]

[1]Udaipur Solar Observatory, Physical Research Laboratory, Udaipur, Rajasthan

[2]Indian Institute of Technology, Gandhinagar, Palaj, Gujarat, 382055, India

[3]Department of Mathematics and Statistics, University of Exeter, Exeter, EX4 4QF, UK

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ABSTRACT

Quiescent prominences are large magnetic structures hosting cool plasma in surrounding million-degree solar coronae. Prominences host different flows that may distort magnetic field lines, which may lead to magnetic reconnection inside the prominence body. In this study, we investigated bidirectional flow patches in a quiescent prominence observed using the Multi-Application Solar Telescope (MAST) of Udaipur Solar Observatory, India. The investigation included the analysis of velocities in the line of sight (LOS) and the plane of sky (POS) of the prominence, complemented with intensity at different spectral positions of the Ca II 8542 Å line. The LOS velocities were obtained using Gaussian fitting to the observed Ca II spectra, whereas the POS velocities were derived from a position–time diagram along a vertical slit in the region of interest (ROI). Complementary to Ca II 8542 Å line scans, EUV intensity images from the Atmospheric Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO) were analysed to investigate the multithermal nature of the observed bidirectional flows. Out of two ROIs, in the first ROI, a large central patch of bidirectional flow was present initially that merged with other patches and disappeared approximately 30 minutes from the beginning, followed by the generation of another set of patches. Co-spatial with diverging LOS flows of order 10 km/sec associated with patch dynamics, POS motions of similar order were also observed in the ROI. Diverging intensity enhancements in different AIA channels, indicating a multithermal nature of bidirectional flows, were observed co spatially with diverging flows in the POS. Similar dynamics were observed in the second ROI. Bidirectional flow patches and the associated dynamics in LOS and POS may be related to magnetic reconnection inside the prominence.

Investigating Nonlinear Quenching Effects on Polar Field Build-up Using Physics-Informed Neural Networks

Jithu J Athalathil[1], M. H. Talafha[2] and Bhargav Vaidya[3]

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[2]Research Institute of Science and Engineering, University of Sharjah, UAE

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ABSTRACT

The evolution of the solar magnetic field is the key factor governing space weather drivers. Accurate forecasting of space weather requires precise modelling of the magnetic field's evolution on the solar surface using methods like Surface flux transport (SFT). Conventionally used SFT modelling techniques involve grid-based numerical schemes, making them computationally expensive. In this presentation, we present a novel, mesh-independent machine learning-based approach using Physics-Informed Neural Networks (PINNs) to simulate the temporal evolution of Bipolar Magnetic Regions (BMRs) on the solar photosphere. The ability of PINNs to solve advection-diffusion equations make it an efficient and accurate technique to simulate SFT equation. We employ this approach to study how nonlinear effects influence SFT models, with the broader goal of improving our understanding and constraints on solar dynamo processes. In particular, we focus on two mechanisms recently proposed to modulate solar cycle amplitudes: tilt quenching (TQ), representing a negative feedback between the cycle strength and the average tilt angle of active regions, and latitude quenching (LQ), indicating a positive relationship between cycle strength and the mean emergence latitude of active regions. Using PINNs within the SFT framework, we systematically examine the nonlinearities introduced by TQ, LQ, and their combined effects. Our study aims to clarify the distinct contributions of TQ and LQ to the solar dynamo. We find that the balance between LQ and TQ effects is closely linked to the ratio of meridional flow speed to magnetic diffusivity in the SFT models. Given that LQ is better constrained through observations, it may offer a valuable benchmark for refining solar dynamo models to achieve closer alignment with solar observations.

Exploring Historical Solar Activity: Neural Network Detection of Plages in Sun charts

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Aryabhatta Research Institute of Observational Sciences, Nainital-263002, Uttarakhand
Department of Applied Physics, Mahatma Jyotiba Phule Rohilkhand University, UP
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Email ID - dibyakirtimishra@gmail.com/ dibyakirtimishra@aries.res.in

ABSTRACT

The Kodaikanal Solar Observatory (KoSO) hosts one of the longest continuous archives of solar observations, spanning over a century and covering multiple wavelengths, including white light, Ca II K, and Hα. In addition to these datasets, KoSO has preserved hand-drawn solar sun charts from 1904 to 2022, annotated with sunspots, plages, filaments, and prominences using the Stonyhurst coordinate grid and distinct color codes. These charts have recently been digitized at high resolution (6k × 6k, .tif format), enabling modern image analysis. In this study, we present the first automated identification of plages in KoSO sun charts over the period 1916–2007 (covering 10 solar cycles), using a supervised machine learning framework based on Convolutional Neural Networks (CNNs). The model is trained on annotated plage masks from a single solar cycle and applied to the full dataset for consistent segmentation. A separate CNN-based model is also developed for accurate solar disk identification, enabling the extraction of disk center, radius, and P-angle. We compare the CNN-derived plage areas with those obtained from corresponding Ca II K spectroheliograms, demonstrating good agreement and highlighting the potential of sun charts to fill gaps in existing KoSO Ca II K plage records. This work provides a new avenue for constructing continuous synoptic maps of solar activity from 1904 to 2007, significantly enhancing historical solar magnetic field reconstructions.

Quiet-Sun Ellerman Bombs and Their Impact on the Upper Solar Atmosphere

Jayant Joshi
Indian Institute of Astrophysics, II Block Koramangala, Bengaluru, 560034

ABSTRACT

Recent high-resolution observations have shown that quiet-Sun Ellerman bombs (QSEBs), thought to be driven by magnetic reconnection in the deep solar atmosphere, are more prevalent than previously known, with about 750,000 present across the quiet Sun at any given time. Analysing Hβ and Hε observations from the Swedish 1-m Solar Telescope, we detected ubiquitous QSEBs characterised by rapid variability and flame-like morphologies. While a subset of these events showed localised heating in the transition region, indicated by UV brightenings in Si IV observations from the Interface Region Imaging Spectrograph, only a small fraction of QSEBs contributed to such heating. Additionally, we found cases where QSEBs were linked to the formation of type II spicules, suggesting that magnetic reconnection could be a driving mechanism for spicules. However, these associations account for only a small portion of the total number of QSEBs and spicules, indicating that QSEBs likely play a limited role in global upper-atmosphere heating and spicule formation.

Solar Jets: Physical Properties and Triggering Processes

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ABSTRACT

Solar jets, which are the collimated flow of plasma along the magnetic fields, are ubiquitous within the solar atmosphere. Therefore, the solar jets have become an integral part of solar physics research. Researchers continuously use imaging, spectroscopic, and magnetic field observations to study the physical properties and triggering mechanisms of solar jets. Various important results about the solar jets, obtained from these observations, help the community to perform advanced numerical simulations of the solar jets. Ultimately, as a result, high-resolution observations and numerical simulations have helped us develop a good understanding of the physical properties and triggering mechanisms of solar jets. In this talk, I will discuss various physical properties and triggering processes of solar jets.

Exploring the Source Region Dynamics of Coronal Transients Utilizing Data - Constrained MHD Simulations

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ABSTRACT

Coronal transients, such as coronal mass ejections (CMEs), solar flares, prominence eruptions, and coronal jets, represent some of the most dynamic and energetic phenomena within the solar atmosphere, carrying significant implications for space weather. A comprehensive understanding of their initiation and early development necessitates a thorough examination of the dynamics within the source region. Recent advancements in both observations and simulations indicate that magnetic reconnection, occurring across various length and energy scales, may play a crucial role in the initiation and subsequent evolution of these transients, as well as in the restructuring of solar magnetic fields. In this presentation, I will elaborate on the commonly employed extrapolation techniques used to generate realistic coronal magnetic fields in the source region by extrapolating the photospheric magnetic field. Furthermore, I will show three-dimensional (3D) magnetohydrodynamic (MHD) simulations that are driven by these extrapolated magnetic fields to model the evolution of active regions that lead to coronal transients. The MHD simulations reveal the significance of key topological features, such as magnetic nulls, quasi-separatrix layers (QSLs), and hyperbolic flux tubes (HFTs), in initiating magnetic reconnection, which subsequently leads to the occurrence of different types of the transient events. Additionally, I will emphasize the critical role of magnetic reconnection in the formation of magnetic flux ropes, which are essential structures for eruptive flares and CMEs.

Probing t he Role of Pre -Eruptive Magnetic Fields and Electric Currents in the Hxr Foot point asymmetry d uring Flares

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ABSTRACT

Understanding the mechanisms behind particle acceleration and energy deposition in solar flares is essential for modeling eruptive events and their space weather impact. In this study, we statistically investigate the asymmetry of conjugate hard X-ray (HXR) footpoints (FPs) in 71 of >M-class flares, observed by Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) mission, with a focus on how magnetic field strength and electric currents regulate the precipitation of flare-accelerated electrons into the lower solar atmosphere. Using vector magnetograms from the Helioseismic and Magnetic Imager (HMI) onboard the Solar Dynamics Observatory (SDO), we derive magnetic field strength and vertical electric current in flaring regions. These parameters are analyzed in conjunction with HXR imaging data from the RHESSI. Ultraviolet observations from the Atmospheric Imaging Assembly (AIA) onboard SDO are used to confirm that the selected events are double-ribbon flares exhibiting a local bipolar configuration consistent with the standard flare model. To reduce projection effects in both footpoint localization and magnetic field measurements, only flares located within ±45° of the solar disk center are considered. Our results reveal a statistically significant correlation between the intensity asymmetry of HXR footpoints and the asymmetry in both unsigned magnetic flux and unsigned vertical electric current. This behavior suggests that the energetic electron precipitation is modulated by the pre-eruptive magnetic structure and electric current distribution, offering insights that challenge conventional expectations from simple magnetic mirroring or electric field acceleration alone. Further insights can be gained by investigating spectroscopic and imaging mode observations of the recent events commonly observed by SoleXs and Hel1os onboard Indian ADITYA-L1 mission and HXI onboard Chinese ASO-S mission.

Numerical Modelling of the Magnetic Reconnection in the Chromospheric Current Sheets

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ABSTRACT

The Sun's atmosphere is dynamic and composed of both magnetic field and plasma where their interplay can produce many localized transient energy release processes at different spatial and temporal scales. Basically the sun's atmosphere consists of a variety of energetic events like flares, ER bombs, and impulsive jets in different parts of the solar atmosphere, where magnetic reconnection may play a key role. In the present work, we have modelled the externally driven chromospheric reconnection by using MPI AMRVAC code. As the chromosphere is partially ionized, the effect of ambipolar diffusion is crucial and its effect on reconnection rate is not fully understood. After the collision of external velocity pulse, reconnection is initiated with bidirectional hot plasma outflow with speed 20 km/sec comparable to the observed speed of the anemone jets in the chromosphere. Due to the inclusion of ambipolar diffusion, an ambipolar electric field (E_{AD}) is generated along the current sheet direction which resists the magnetic field to reconnect at the 'X' point and increase the plasma pressure and temperature between the CS. As a result, the reconnection rate is decreasing for the higher ambipolar diffusion.

Radio Insights on Large -Scale Chromospheric Flows: A study using Nobeyama 17 GHz Data

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ABSTRACT

Understanding solar differential rotation across atmospheric heights is essential to deciphering the solar. Traditional measurements based on EUV and optical observations often suffer from uncertainties in height attribution due to temperature-dependent emission. In this study, we analyze over two solar cycles (1992–2020) of full-disc 17 GHz radio imaging from the Nobeyama Radio heliograph (NoRH), which offers a more height-stable diagnostic of the upper chromosphere. A tracer-independent, automated image correlation technique was employed to extract rotation rates across 16 latitude bins. The resulting profile reveals a significantly faster and less differential rotation in the upper chromosphere compared to the photosphere, with best-fit coefficients consistent with previous chromospheric estimates derived from EUV diagnostics. A weakly significant anti-correlation between the equatorial rotation rate and solar activity was observed. These findings reinforce the utility of radio wavelengths in isolating atmospheric rotation layers with minimal ambiguity often associated with using tracers of the higher atmosphere which often comprise of multi-thermal plasma.

Solar Chromospheric Differential Rotation across Latitudes Using Ca -K Line Features from Kodaikanal Observatory

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ABSTRACT

The Sun's magnetic fields and their activity are largely driven by its fundamental characteristic of differential rotation.Therefore, it is important to study the differential rotation for better understanding the physical mechanisms behind the various solar activities and cycles. We studied the rotation rate of chromospheric features such as plages, enhanced network (EN), active network (AN), and quiet network (QN) separately, using digitized Ca-K images from the Kodaikanal Observatory spanning 1907-1996, across latitudes from 0° to 80° at 10° intervals.We find that plages and all types of networks exhibit the differential rotation of the chromosphere. Furthermore, the rotation rate shows a decreasing pattern as one move from the equator to the higher polar latitudes for all the features used in the study. At the equator the rotation rate (rotation period) is obtained to be ~13.98° day^{-1} (25.74 days), ~13.91° day^{-1} (25.88 days), ~13.99° day^{-1} (25.74 days), and ~14.11° day^{-1} (25.51 days) for plage, EN, AN, and QN areas, respectively. By analyzing how the area of chromospheric features varies over time, we can effectively map the Sun’s rotation rate at all latitudes, including the polar regions. Interestingly, both plages and small-scale networks exhibit a similar differential rotation rate. This suggests these features likely rooted at the same layer below the visible surface of the Sun. Therefore, the long-term Ca-K data is very useful for studying the solar rotation rate at all latitudes including the polar regions.

On spatial distribution of umbral dots

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ABSTRACT

Context: The umbral dots (UDs) present in the highly magnetized medium of a sunspot's umbra are understood as the signatures of small-scale magneto convection. In addition to the usual UD's distribution as peripheral and central UDs, we observe their spatial distribution to be non-uniform, as well as crowded at specific locations.

Aim: Our work aims to determine the spatial distributions of UDs as well as to analyse how it changes with different ambient conditions of the umbra, like in the presence of light bridges and distorted penumbra.

Method: We utilize blue continuum fitergrams of 25 sunspots from the Solar Optical Telescope (SOT) onboard Japanese satellite Hinode observed between 2006 and 2015. We adopt multi-level tracking (MLT) algorithm to identify the UDs and incorporate machine learning (ML) techniques like density based clustering (DBSCAN) algorithm to be able to determine their spatial distribution, both of which are programmed in IDL.

Structure of the photosphere and the corona — new insights with Solar Orbiter

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ABSTRACT

Heating of the solar corona to a million Kelvin and the acceleration of the solar wind remain two of the most outstanding problems in stellar astrophysics. There is a growing evidence that magnetic processes on spatial scales of less than 1000 km, operating in the solar atmosphere, are central to solving these problems. In this context, it is important to understand how the magnetic energy from the solar surface is channelled to heat the overlying corona and drive the solar wind. New observations from Solar Orbiter, for the first time, capture surface magnetic structures and coronal features at almost exactly the same high spatial resolution of 200 km. These unprecedented observations reveal a highly dynamic surface magnetic landscape and shed new light on magnetic reconnection, a fundamental astrophysical process, operating on small spatial scales in the solar corona. I will present these new results and discuss implications for the coronal heating and solar wind models.

Fine-Scale Heating Events in the Solar Atmosphere Revealed by Recent High-Resolution Telescopes

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ABSTRACT

High-resolution observations have long been pivotal in advancing our understanding of the solar corona—a multi-million-degree plasma that plays a crucial role in driving space weather. In this talk, we present observations of fine-scale, short-lived bursts—spanning spatial scales of a few hundred kilo- meters and life times under one minute—captured in EUV emission (e.g., 172 Å and 193 Å) using modern high-resolution instruments such as Hi-C rocket flights, IRIS, and Solar Orbiter's EUI/HRI. These heating events include, but are not limited to, dot-like brightenings in sunspot penumbrae, active region cores, quiet Sun areas, and coronal bright points, as well as fine-scale jets, jetlets, and loops through out the solar atmosphere. Additionally, we incorporate insights from a 3D Bifrost MHD simulation to investigate dot-like heating events as substructures within a coronal bright point. Investigating small-scale bursts provides critical insight in to the physical processes that power larger solar events, contributing to coronal heating and the generation of space weather.

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An X-ray Perspective on Solar Flares

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ABSTRACT

Solar flares emit radiation with intensities ranging over several orders of magnitude from large X-class flares to microflares to hypothesized nanoflares that may be responsible for maintaining the solar corona at millions of Kelvin temperatures. Investigations of multi-scale solar flares, from large flares to the smallest microflares, are key to the missing pieces in our understanding of the flaring process as well as coronal heating. Observations in the X-ray wavelengths offer one of the most direct diagnostics of thermal plasma and non-thermal accelerated electron populations in solar flares, as they emit profusely in soft and hard X-rays.

Solar X-ray Monitor (XSM) onboard the Chandrayaan-2 mission provides disk-integrated X-ray spectral measurements of the Sun in the energy range of 1-15 keV, with a high dynamic range to observe sub-A class micro flares to large X-class flares. XSM is about to complete six years of continuous solar observations starting from the last solar minimum, and in this talk, I will highlight some of the major results using XSM observations on various aspects of multi-scale solar flares, particularly on the thermal plasma parameters and elemental abundances. I will also introduce other recently operational solar soft X-ray spectrometers on other missions and on the advantages of simultaneous analysis of soft X-ray spectra with the hard X-ray spectra from instruments such as Solar Orbiter STIX and Aditya L-1 HEL1OS. Finally, I will discuss how flux measurements with soft X-ray spectroscopic observations of the Sun, such as with XSM, compare with regular monitoring observations with GOES satellites.

Probing the Physics of Radiation and Particles Emitted During Energetically - Rich Solar Flares

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ABSTRACT

Solar flares are energetic and dynamic phenomena in the Solar System, emitting radiation and solar energetic particles (SEPs) of several Me vs. Magnetic reconnection is believed to transform non-potential magnetic energy, thereby energising the ambient plasma and producing a nonthermal pool of electrons (NTEs) and solar energetic particles (SEPs). Therefore, the characterisation of such flare-associated plasma allows inferring the crucial acceleration and heating mechanisms. By reconciling multi-wavelength observations,the standard flare energy release scheme puts forth the physical mechanism responsible for the radiation and particle emission during flares. However, this scheme is often challenged by the observations, particularly during weak flares that remained less investigated in the past owing to observational limitations.

In this regard, our investigation of the X-ray emission and solar energetic electrons (SEEs)emitted during solar flares using the observations acquired bythe Solar Orbiter mission of ESA and NASA enables bridging the gap in our understanding of the “energetic-richness” of the flares and the role of magnetic reconnection. In this regard, we will present the investigation of 1) partitioning of thermal-nonthermal emission during flaresand 2) the processes governing the acceleration efficiency of charged particlesenergised due to magnetic reconnection phenomena. By carefully investigating the spectral, spatial and dynamical characteristics of in-situ electron and flare-related nonthermal electrons, we aim to constrain the nature of interaction of NTEs with the different layers of the solar atmosphere. This also enabled establishing the physical constraints of the energization and acceleration of flare plasma from the solar atmosphere to the interplanetary space. Investigations of such a diverse set (remote+in-situ) of observations help enrich our knowledge of the energetics of the seed electron population in the solar atmosphere, transport effects, and thus enable a refined space-weather prediction.

Modelling the Wave Dynamics of Solar Atmosphere to Study Coronal Heating

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ABSTRACT

Heating in the solar atmosphere has long remained one of the central unsolved problems in solar physics. Despite significant progress in both observational capabilities and theoretical modeling, the precise mechanisms responsible for maintaining the high coronal temperatures continue to be debated. Among the proposed candidates, wave heating — particularly via p-mode-driven magneto hydrodynamic (MHD) waves interacting with structured magnetic fields — has attracted increasing interest. In this study, we present a comprehensive study of MHD waves through 2.5D MHD simulations to examine the influence of various wave drivers and magnetic field configurations on wave propagation, mode coupling, and energy transport in the solar atmosphere. Our results show that employing a realistic broadband driver for p-mode oscillations produces power spectra peaking around 4 mHz, which is in close agreement with observations. Furthermore, we simulate solar jets and study wave generation under the influence of p-mode oscillations. It is found that p-mode-like oscillations can enhance high-frequency transverse oscillations in the chromospheres and generate a coronal power spectrum with frequencies peaking around 3.5–3.7 mHz. These results provide further insight into the role of wave-driven processes in coronal heating and highlight the dynamic coupling between photospheric motions and coronal oscillations.

Inner-Heliospheric Signatures of Steadily Declining Solar Magnetic Fields and their Possible Implications

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ABSTRACT

We examined solar photospheric magnetic fields for the solar cycles 21–25, covering the period 1975–2024. The unsigned photospheric magnetic fields at low latitudes (0°–45°), known as solar toroidal fields, showed a solar cycle variation with the total field strength being stronger during the maximum of cycle 25 than the maximum of cycle 24. However, the unsigned field strength of photospheric magnetic fields at high latitudes (45°–78°), known as solar polar fields, has shown a significant steady decline since around the mid-1990s. The unsigned field strength of solar polar fields, after an increase during 2015–2020, has declined again until 2024, continuing the declining trend for a long 30yr. Also, we examined the solar wind microturbulence levels in the inner heliosphere (0.2–0.8 au), using interplanetary scintillation observations at 327 MHz, covering the period 1983–2024, that steadily declined since the mid-1990s and continued until 2024, synchronously with the solar polar fields. In addition to the steadily declining magnetic fields, we found that the floor level in both solar toroidal fields and solar wind magnetic fields was reduced during the minimum of cycle 23 and recovered back during the minimum of cycle 24. Also, a hemispherically asymmetric solar polar reversal was evident in the signed (axial) solar polar fields during cycles 21–25, with the reversal in cycle 25 for the northern hemisphere completed earlier than the southern hemisphere. In the presentation, I will discuss the implications of such long declining trend and other anomalies in solar cycle magnetic activity.

Exploring Solar Jet Onset, Evolution, and their Associated Magnetic Topology through a Data -Constrained Magneto Hydrodynamics Evolution of Active Region AR13141

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ABSTRACT

Solar jets are collimated, beam-like plasma ejections and are ubiquitous in solar atmosphere. They are crucial in understanding solar activities at different scales such as magnetic reconnection, coronal heating, and particle acceleration. Contemporary research hasadvanced the understanding of different aspects of solar jet, such as their triggering and driving mechanisms but not fully understood and remains an open problem. This work attempts to explore the triggering and driving mechanism by means of data-based magnetohydrodynamics (MHD) simulation of an active region NOAA 13141, which host a jet on November 10, 2022, starting around 03:12 UT. The simulation started with an extrapolated initial magnetic field obtained from employing the Non-Force Free extrapolation model to the photospheric vector magnetogram of active region NOAA AR13141 at 03:00 UT (before the jet onset). Importantly, the initial extrapolated field shows the presence of a three-dimensional (3D) null (named as pre-existing null) co-located with jet activity region. The initial non-zero Lorentz force initiated the dynamics of the plasma. The simulation shows the magnetic reconnection (MR) associated with the pre-existing null manifests as the initial brightening before the start of the jet. Further evolution shows the spontaneous generation, evolution, and annihilation of nulls in a pair via MR and contributed in initiating and driving the jet. The appearance and disappearance of spontaneously created 3D nulls have been also confirmed by locating them in the extrapolated magnetic fields before the jet (at 03:00 UT), onset of jet (at 03:12 UT) and after onset of the jet (at 03:24 UT). Such a spontaneous creation and annihilation of nulls and their association with magnetic reconnection along with jet activity can explain the coronal heating, particle acceleration, and can contribute to the solar wind.

ASPEX on-board Aditya -L1: Heliospheric, Solar Wind and Space Weather Science Potential

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ABSTRACT

Aditya-L1 is India's first dedicated solar observatory placed at the first Lagrange point (L1) of the Sun-Earth system. It was launched using Polar Satellite Launch Vehicle (PSLV-C57) of ISRO on 02 September 2023. After a few earth-bound orbits, the cruise phase of Aditya-L1 started on 19 September, 2023. The satellite was successfully inserted into the Halo Orbit on 6 January 2024. There are seven experiments on-board Aditya-L1 out of which four are remote sensing experiments and three are meant for in-situ measurements. The in-situ measurements include the Aditya Solar wind Particle Experiment (ASPEX) which is conceived, designed and developed at the Physical Research Laboratory. ASPEX makes solar wind measurements through two spectrometers – one for low energy and the other for higher energy. The low energy spectrometer is known as Solar Wind Ion Spectrometer (SWIS) that measures solar wind protons and alpha particles in the energy range of 100 eV – 20 KeV energy range. SWIS can measure solar wind and low energy suprathermal ions in the field of view of 360o in and across the ecliptic plane in an angle-resolved manner. The high energy spectrometer is known as SupraThermal and Energetic Particle Spectrometer (STEPS) that measures solar wind energetic ions in the energy range 20 keV/n – 6 MeV/n in six different directions. Therefore, ASPEX is capable of making directional measurements of solar wind at both low and high energies from a three–axis stabilized spacecraft. In this talk, I will present a few recent results to highlight the importance of ASPEX in the context of unravelling the secrets of heliosphere, solar wind and space weather.

Turbulence and Intermittent Structures at Kinetic Scales in Solar Wind

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ABSTRACT

Solar wind is highly turbulent with energy spreading and cascading over a wide range of scales from the size of the solar system down to electron scales. These different scales are governed by different physics with large scales showing fluid behaviour and sub-ion gyro-radius scales showing kinetic behaviour. We perform particle-in-cell simulations which show relative abundance of kinetic Alfvén waves at sub-ion scales over whistler waves. We find strong intermittency at these kinetic scales manifested in the form of thin current sheets. We use clustering techniques to identify these current sheets in our simulations and measure their thickness. They mostly seem to have electron skin depth size thickness. We also measure intermittency in solar wind data obtained from the NASA - Magnetosphere Multiscale Mission (MMS) magnetometer. These data also show current sheets that are thinner than the ion scale. These results have important implications for understanding the heating mechanism of the solar wind.

Examining the Mesoscale Inhomogeneity in a CME Substructure near 1 AU

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ABSTRACT

Understanding the global characteristics of coronal mass ejections (CMEs) from single- or multipoint in situ measurements can help in predicting the space weather effects. We focus on examining the mesoscale differences/similarities in the characteristics of a magnetic cloud (MC), a CME substructure, across the two spacecraft STEREO-A and Wind near 1 AU. We found the differences in the estimates of the arrival times of CME substructures and the orientation of the MC axis between the two spacecraft. We also propose a novel approach to investigate the nonisotropic compression of the MC along its angular extent by comparing the arrival of the MC axis with the arrival of the size and time center of the MC. Using minimum variance analysis (MVA), we estimate the orientation of the MC at both spacecraft; we note that the MC is slightly out of the ecliptic at Wind but not at STEREO-A. We also compare the magnetic field parameters from the start to the end of the MC at both spacecraft. Our findings show a significant non-coherency towards the rear edge portion of the MC. Notably, the trailing edge shows stronger compression at STEREO-A than at Wind. This suggests that inferring the global characteristics of CMEsfrom local in situ measurements is challenging. Our study questions the coherent structure of the CME, even at mesoscales, and highlights the inhomogeneity in the CMEs that could be either inherent or originate during their evolution.

Interaction Regions at 1 AU

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ABSTRACT

Corotating Interaction Regions (CIRs), formed by the interaction between slow and fast solar wind streams, provide an ideal environment for studying plasma waves and instabilities. In this study, we analyze 290 CIR events using Wind spacecraft data at 1 AU during Solar Cycle 24 (2008–2019) to explore the relationship between proton temperature anisotropy and kinetic instabilities. Our results show that the Mirror Mode (MM) and Oblique Firehose (OFH) instabilities primarily regulate temperature anisotropy within CIRs for $\frac{\perp}{\parallel} > 1$ and $\frac{\perp}{\parallel} < 1$ respectively, even at $_{\parallel} \leq$ 2.Although Proton Cyclotron Instability (PCI) is theoretically expected to operate at low $_{\parallel}$our observations and linear instability analysis suggest that for a growth rate of $= 10^{-3}\Omega$ PCI does not significantly constrain or limit the anisotropy in CIRs, potentially due to inefficient energy extraction or the stabilizing effects of minor ions. However, the present study does not account for the effects of collision age and the presence of heavy ions, which may also influence anisotropy constraints in CIRs. Moreover, for $_{\parallel} \geq 2$, the anisotropy is constrained by a combination of MM, PCI, and firehose instabilities. These findings highlight that the mechanisms constraining temperature anisotropy in CIRs are consistent with those in the ambient solar wind and interplanetary coronal mass ejection's sheath, underscoring the robustness of these regulatory processes across different heliospheric environments.

Interplanetary Magnetic Field (IMF) Fluctuations during Solar Transient Events: Observations by MAG Payload Onboard Aditya-L1 Spacecraft

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ABSTRACT

Onboard the first Indian solar mission, namely Aditya-L1, to study the Sun, the dual sensor triaxial fluxgate magnetometer (MAG) is continuously measuring the interplanetary magnetic field (IMF) in a halo orbit around the first Lagrangian (L1) point. After the L1 orbit insertion in January, 2024, the MAG boom was deployed on which the two sensors are mounted and the regular recording of the local IMF commenced which varies between 5 – 10 nT in an earth day. Since then, MAG has observed several solar extreme transient events till date during which the IMF magnitude increased significantly. Out of a number of such events, 3 events namely during March 22-24, May 10-13, and October 10-11, 2024 are chosen for the present study. During these events, the analysis of IMF power spectra shows the fluctuations that are consistent with Kolmogorov turbulence slope near -5/3. To understand this spectral behavior, the spectra of transient event are compared with the spectra of a non-event day IMF which shows a stark difference. The spectra of non-event days exhibit the anisotropic turbulence whereas the transient event days exhibit the quasi-isotropic behavior. However, the IMF power spectra follow the Kolmogorov slope for all the three magnetic field components.

Solar Filament Eruptions and Coronal Loop Dynamics

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ABSTRACT

Solar filaments, also known as prominences, are cool and dense plasma structures suspended in the solar corona, maintained by a balance between magnetic tension and pressure. Occasionally, this balance can be disturbed, leading to the ejection of filaments from the sun. During such eruptions, an interesting phenomenon is observed: a change in the geometry of coronal loops or loop systems. These loop systems are distinct from flare loops and are often located near the foot point of the erupting filament. In this talk, I will present observations and possible interpretations of coronal loop dynamics during solar eruptions, based on data from the Solar Dynamics Observatory.

Long-Period Decay less Kink Oscillation Detected in Solar Coronal Loop

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ABSTRACT

Transverse magnetohydrodynamic (MHD) oscillations in coronal loops provide an effective probe of plasma conditions and magnetic field structuring in the solar atmosphere. In particular, decayless kink oscillations—small-amplitude transverse displacements that persist without attenuation—are believed to play a role in energy transport. However, prior observations have been limited primarily to loops with periods between 2 and 10 minutes.

In this work, we report the detection of a long-period decayless kink oscillation in a solar loop with a projected length of 248.4Mm, captured by the High-Resolution Imager in EUV(HRIEUV) onboard Solar Orbiter. A time–distance analysis at the loop apex reveals clear transverse shiftsthat followa sinusoidal profile.Fitting yields a period of 75.33±1.88minutes, while wavelet power analysis identifies a consistent dominant period of 62.90minutes.

Using the standing kink mode relation, we estimate the corresponding phase speed to be around 110km/s,considerably lower than typical values in the corona (500km/s to 1500km/s).This deviation likely results from projection effects or fine-scale density structuring.The absence of damping during the observation confirms the decayless nature of the oscillation.

These findings expand the observed range of decayless kink parameters and confirm the capabilities of HRIEUV in detecting weak transverse displacements. Most importantly, they lend further support to the idea that persistent transverse MHD waves could contribute to energy deposition and help resolve the long-standing solar coronal heating problem.

Numerical stud y of a B-class flares using the XSM, GOES, HMI/SDO and AIA/SDO

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ABSTRACT:

Solar flares are sudden explosive events on the Sun that convert magnetic energy into heat and accelerate charged particles along with a rearrangement of magnetic field lines (MFLs): the process of magnetic reconnection. Typically, energy released in a solar flare may vary over a large range $\in \{10^{23}, 10^{32}\}$ erg. The energetically large flares, under suitable conditions, affect the near-Earth space weather and have been studied extensively. Contrarily, the small flares are less explored since their detection requires more sensitive observations. However, a systematic and holistic study of these small flares can contribute to the physics of small-scale magnetic reconnection, directly bridging an abundance of research problems related to coronal/chromospheric heating, coronal jets, and other relevant phenomena observed in the solar atmosphere. Consequently, this work focuses on exploring a GOES (Geostationary Operational Environmental Satellite) B-class flare---loosely classified as a "microflare" --- through a combination of multi-instrument data, augmented with three-dimensional data-constrained magneto hydrodynamics simulation. The expectation is to use the synergy between observations from GOES, XSM (Solar X-ray monitor) on board Chandrayaan-2; AIA, HMI onboard SDO; and data-constrained MHD simulations using the well-established EULAG-MHD model to develop a framework aiming to understand small-scale reconnections in the solar corona.

High-Resolution Observations of Transverse Waves in the Solar Corona: From Loops to Plumes

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ABSTRACT

Transverse waves are prevalent in the solar corona and can be observed at various spatial and temporal scales. Since the launch of the Solar Orbiter, these waves have been studied with high spatial and temporal resolution.

In this presentation, I will provide observational evidence for the existence of transverse waves in short coronal loops, which are approximately 10 Mm in length, found in active regions, quiet regions, and coronal holes, using the data from Solar Orbiter. Additionally, I will present observations of propagating waves within polar plumes. Finally, I will discuss the energy content of these waves and their significance in the heating of the solar corona.

Source sizes of type II radio bursts

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ABSTRACT

Solar radio bursts can provide important insights into the underlying physical mechanisms that drive the small and large-scale eruptions on the Sun. Since metric radio observations can give us direct observational access to the inner and middle corona, they are often used as an important tool to monitor and understand the coronal dynamics. While the sizes of the radio sources that can be observed in the solar corona is essential for understanding the nature of density turbulence within the solar corona and its subsequent influence on the angular broadening observed in radio source measurements, the smallest radio sources associated with solar radio bursts have so far been limited by observational techniques and the radio instrument's baselines. We selected three type II bursts that were observed with the LOFAR core and remote stations in the Solar Cycle 24. We estimated the sizes and shapes (ellipticity) of the radio sources between 20 − 200 MHz using a two-dimensional Gaussian approximation. Our analysis shows that the smallest radio source size for type II bursts in the solar corona which can be observed in the solar atmosphere at low frequencies is $1.5' \pm 0.5'$ at 150 MHz. However, even though the observations were taken with remote baselines (with a maximum distance of ∼ 85 km), the effective baselines were much shorter (∼ 35 km) likely due to snapshot imaging of the Sun. Our results show that the radio source sizes are less affected by scattering than suggested in previous studies. Our measurements indicate smaller source sizes at frequencies below 95 MHz compared to previous reports, though some overlap exists with measurements at higher frequencies, using smaller baselines.

Mutual Association of Waves and Reconnection in the Solar Corona

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ABSTRACT

Magnetic waves and magnetic reconnection are two fundamental magneto plasma processes ubiquitously taking place in the solar corona. We will discuss an overview of their possible mutual interactions and coexistence in which onset of one occurs at the expense of the other and properties of one are controlled by the other one using magneto hydrodynamic simulations. Specific magnetic structures such as magnetic nulls can collapse in response to its interaction with magnetic waves due to resultant Lorentz force generated via such interactions. Such collapse can result in formation of a current sheet which is necessary to initiate magnetic reconnection and further coronal heating. Hence, formation of current sheet and magnetic reconnection will depend on the properties of magnetic waves. On the other hand, impulsive reconnection in presence of plasmoids and their coalescence can act as a source of in-situ magnetic waves in solar corona. Such waves can then transport energy to larger distances from the reconnection site sufficient for coronal heating and driving solar winds. Therefore, mutual association between magnetic waves and magnetic reconnection plays an important role in coronal heating and energy transport at diverse spatio-temporal scales in solar corona. Focused observational studies are highly required for better quantification of role of such association in sustentation of high temperature in solar corona. Such mutualism is referred to as a "Symbiosis of Waves and Reconnection (SWAR)".

Exploring Flare Onset and Flare –CME Coupling: Multi -Instrument Observations of a Superfast CME Associated with an X3.3 -Class Flare from HEL1OS/Aditya -L1, Udaipur -L WA, and AIA/SDO

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ABSTRACT

The Three-part CME model successfully provides us with a fundamental framework to understand the early CME morphology and dynamics. However, the relation between non-thermal emission with early flux-rope evolution and dynamics remains poorly understood. To probe this aspect, we present a detailed multi-instrument analysis of an X3.3-class solar flare that occurred on 24 October 2024 in Active Region 13872, located at S16E76. This eruptive flare was associated with a superfast halo coronal mass ejection (CME) exhibiting a speed of approximately 2385 km/s. The analysis is carried out using EUV imaging from AIA/SDO, hard X-ray measurements from HEL1OS/Aditya-L1, and low-frequency dynamic radio spectrograms from the Udaipur-LWA. The flare onset was marked by type III radio bursts between 03:39 UT and 03:41 UT, indicating the escape of electron beams into the heliosphere. This was followed by a type II radio burst from 03:41 UT to 03:58 UT, associated with the CME-driven shock. Concurrently, HEL1OS recorded a significant hard X-ray peak in the 80–150 keV energy band at approximately 03:50 UT, coinciding with the impulsive phase of energy release and particle acceleration. The tight temporal correlation between these signatures supports a scenario in which magnetic reconnection in the corona initiates both the flare and CME, leading to rapid energy release and outward propagation of a shock. This work underscores the importance of multi-wavelength observations in understanding the coupling between solar flares and CMEs, particularly for understanding the association between non-thermal flare-associated parameters with early CME dynamics.

A Spatio-Temporal Study of a Steady Supersonic Downflow in AR 12135 using IRIS data

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ABSTRACT

Flows in active regions have been a long-standing region of interest owing to their connection with the mass and energy transfer in the upper Solar atmosphere. Super-Sonic down flows (SSDs), a very unique phenomenon, are usually observed above sunspots as red shifted components in the transition region spectral lines. These localised transient events occur in more than 80 per cent of sunspots, often recur at the same location within a timescale of a few minutes to hours and their speed ranges between 50 to 200 km/s. Short-lived and Rapid SSDs are previously linked to Coronal Rain, while the exact origin of Steady SSDs remains debatable. In this work, we investigate the short-term dynamics of a steady SSD in AR 12135 by utilizing a nearly 3-hour Interface Region Imaging Spectrograph (IRIS) dataset. After carefully checking the spectra, we performed triple Gaussian fitting with specific constraints to transition region spectral lines on each pixel to study the spatial morphology as well as the temporal variation of this event. Our analysis revealed that the down flow is initially seen in both the umbral and penumbral regions. Over time, the penumbral down flow fades, while the umbral down flow strengthens and appears as a single structure that eventually splits into two spatial segments. By combining IRIS spectroscopic observations with imaging data from the Atmospheric Imaging Assembly (AIA), we found that on certain occasions, the down flow seems to originate from the region between the hotter plasma loops. We also derived average properties like down flow speed, electron density, and mass flux of this event over the umbral region.

Flare Ribbons and Reconnection Dynamics in an M3.4 Solar Flare from NOAA AR 13668: Evidence of J -Shaped Flare Ribbons

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ABSTRACT

Solar flares are the events driven by magnetic reconnection occurring in the solar atmosphere. These events typically show complex, multi-thermal and morphological signatures between different atmospheric heights. In this paper, we studied a multi-wavelength analysis of an M3.4 solar flare in NOAA Active Region (AR) 13668 on 2024 March 8 by taking data from the Atmospheric Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO). The event has characteristics of flux emergence. The J-shaped form of flare ribbons, the evolution of pre- and post-flare loops are the signature of magnetic reconnection. Normalised intensity profiles from the 335 Å, 171 Å, 1600 Å, and 304 Å AIA channels show a rapid rise in emission starting around 02:20 UT with peak times and decay phases that are wavelength dependent, suggesting a complex multi-thermal response. The observed flare ribbons in the 1600 Å and 304 Å channels are in the shape of J-loops, suggesting the presence of twisted magnetic field. Lagged emission peaks in the hotter coronal channels are interpreted as evidence of second-stage heating of overlying loops because of reconnection driven energy release. These findings show how magnetic reconnection, chromospheric evaporation, and coronal loop reactions are connected. They also highlight how using multiple imaging channels at the same time can help track how solar flare activity changes over time and space.

Relation between the Ca II (H & K) lines and Mg IIlines during Solar Cycle 24

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ABSTRACT

We study the chromospheric activity proxiesof Mg II and Ca II (H&K) lines of intensity of the solar activity components profiles during solar cycle 24 (January 2008 to December 20219). It is the best-known chromospheric activity proxies are the Ca II (H&K)lines, with their wavelength representing the two strongestlines in the visible solar spectrum, the H line at 3968.469 Åand the K line at 3933.663 Å. We investigate the intensity variation and short-term periodic variation of the Mg II and Ca II (H&K)lines of the Sun to better understand their nature. We observed a solar rotational period of ~25 daysof Mg II and Ca II (H&K)lines, and their distinctspectrum profiles were produced by wavelet methods. The periodogram Robper methods are derived from the periodic profiles of Mg II and Ca II (H&K)lines. To investigate the relation between the photosphereand chromosphereproxies. The H and K lines of Ca II share similarbehaviourto the Mg IIlines, with a strong correlation coefficient is 0.995 by the linear fit method.

Prominence Eruption rather than the on -Disk Solar Flare

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ABSTRACT

Decimetric solar radio emissions usually have been found to be causally associated to the flare activity sites. However, we present observations of off-limb decimetric radio emission, imaged using the MingantU Spectral Radioheliograph (MUSER) located in China that operates in the frequency range of 0.4 to 0.8 GHz, providing high spatio-temporal resolution (10.3" to 51.6" and 25 ms). We recorded a Type III radio burst on November 11, 2014, at 04:23:30 UT, which was co-temporal with a C-class solar flare that peaked at 04:24:26 UT, as revealed by GOES (1-8 Å) and RHESSI (3-12 keV). EUV and X-ray imaging observations from SDO/AIA and RHESSI indicated that the flare activity occurred on the solar disk. In contrast, the MUSER imaging observations revealed a potential radio source at 762.5 MHz, located approximately 1300" away from the primary flare activity site, on the eastern solar limb. Magnetic field extrapolations using the Potential Field Source Surface (PFSS) model showed no connectivity between the flare activity and the radio source region, indicating that this radio burst event has no connection to the flare. To investigate the cause of this radio burst event, we conducted a multi-wavelength analysis. Imaging observations at AIA 131 Å revealed the onset of a plasma eruption at 04:23:32 UT, originating from behind the solar limb and coinciding both temporally and spatially with the burst activity. A loop opening was also observed at 04:24:44 UT in the AIA 131 Å and 94 Å images. Subsequently, at 04:27 UT, AIA 304 Å imaging observations indicated the evidence of the prominence eruption, confirmed by GONG-Hα images. Based on our multi-wavelength analyses, we conclude that this radio activity is associated with a prominence eruption from the far side of the Sun and is not connected to the flare activity. This represents a rare occurrence where the radio event is co-temporal with flare activity but lacks any physical connection to the primary flare site.

Multi-Wavelength Study of Solar Flares and Associated Eruptive Activities from NOAA 3664: SDO and ADITYA L1 Observations

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ABSTRACT

In the present work, we have investigated Multi-wavelength observations of NOAA active region 3664 from Solar Dynamics Observatory and ADITYA L1. This Active region was a source of many intense solar activities (Solar flares and CMEs) in May 2024. The magnetic field measurements from HMI show magnetic complexity of AR3664. Active region under study appears from May 8, 2024 and lasted till 14 May 2025 and unleashed a series of significant solar events, including X& M-class flares. These activities also associated with several coronal mass ejections (CMEs).NOAA 13664 was rounding the southwest solar limb on 14 May and produced very strong solar flare of class X8.7. We performed multi-wavelength analysis from SDO and ADITYA L1 observations for the AR3664. The preliminary results indicate that magnetic configuration of the active region was highly complex and capable of producing multiple flares and CMEs.

Multiscale Features Inside ICMEs

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ABSTRACT

Understanding the varying geoeffectiveness of interplanetary coronal mass ejections (ICMEs) and corotating interaction regions (CIRs) remains a major challenge in space weather research. While some events induce only mild geospace responses, others trigger intense geomagnetic storms, indicating that large-scale features alone cannot account for their impact. The evolution of these structures as they propagate through the heliosphere plays a critical role. Contrary to earlier views of ICMEs as coherent large-scale structures, in situ observations reveal complex internal features, including distorted and small-scale flux ropes, current sheets, magnetic islands, plasmoids, planar magnetic structures, heated plasma regions, highly turbulent zones, and regions superposed with MHD and kinetic-scale fluctuations. Gaining deeper insight into these multiscale features, their origins, evolution and interactions is essential for improving our ability to assess and predict their geoeffectiveness.

Fostering Synergy between Magnetohydrodynamic Space Weather Modeling and in-situ space-based data.

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ABSTRACT

Space weather poses significant risks to technical systems and the global economy, making it a critical area of research. Coronal Mass Ejections (CMEs) are the primary drivers of space weather and can cause intense geomagnetic disturbances. The solar wind (SW) governs CME propagation in the heliosphere and drives geomagnetic storm activities. Understanding the evolution of SW stream interaction regions (SIRs), CMEs, and their interactions in the inner heliosphere is essential for accurately predicting their arrival times and mitigating their impacts. In this seminar, I shall describe Space Weather Adaptive SimulaTion (SWASTi), a newly developed three-dimensional magnetohydrodynamic (MHD) modeling framework, emphasizing its SW and CME modules. I shall present comparative results with in-situ observations to showcase the model's efficacy. Our study reveals that ambient SW conditions significantly influence the CME's morphological and dynamical properties. The impact of CME-CME interaction will also be discussed. The talk will further demonstrate how Aditya L1's in-situ measurements can enhance SWASTi's capabilities and will particularly focus on ASPEX and MAG payloads onboard Aditya L1 to provide critical plasma metrics at the L1 point, which can be simulated via our 3D MHD-based SWASTi model. Additionally, I shall describe how the magneto-sphere ionosphere coupling module is integrated within the SWASTi framework to study the impact of space weather drivers (SW, SIRs and CMEs) on planetary ionosphere current systems including impact of transient flux transfer events. Finally, I shall enlist the extensions and applications of such a framework so as to provide a synergy to existing in-situ data from Aditya L1 and upcoming planned planetary and Lunar missions.

Space Weather during Extremely Disturbed Geomagnetic Field and CR Variations

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ABSTRACT

The interaction between solar wind and terrestrial magnetosphere depends up on the plasma structures present in the solar wind. This interaction builds a chain of activities on the geo- magnetic environment. However the intensity of these activities depends up on the orientation and the strength of IMF Bz embedded within the solar wind. One such plasma structure is a magnetic cloud identified by its unique and measurable features. It is a kind of large scale interplanetary solar wind plasma structure resulted as a transient ejection of the solar plasma in the solar wind. Its characteristics were first time reported in 1981 by a group of scientists, who have studied the solar wind ejection with the help of several satellites data simultaneously. Present study deals with the behaviour of these interplanetary magnetic clouds and the behaviour of ground level enhancement events (GLEs) as well as studying the Forbush decrease events simultaneously. We studied these events during the phase of highly intense or ultra-intense geomagnetic field perturbations. We have utilized the IMF and Solar data provided by Omniweb-NASA and the geomagnetic data obtained through magnetometers, measured and provided by WDC Kyoto. Events are further investigated using the data of SIS/ Ulyssesto find He and HeO concentrations. Our results indicate that energetic particles coming from deep surface interact with these abnormal solar and IP conditions (Magnetic clouds) and suffer modulation effects. It is found that AP and AE indices show rise before the forward turnings of IMF, while the Dst index depicts a classic storm time decrease. The analysis indicates that the magnitude of all the responses depends on BZ component of IMF being well correlated with solar maximum and minimum periods.

Simulating the Eruptive Flux Ropes using Data -Driven Magneto frictional Approach

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ABSTRACT

Flares and coronal mass ejections are significant eruptive events on the sun that influence space weather and technology reliant on space. These events happen because of the release of magnetic energy that was previously stored in the coronal field by plasma motions at the surface. Gaining deeper insights into the processes of storing and releasing magnetic energy requires an understanding of how the magnetic field evolves. Direct observations of coronal magnetic fields are challenging to acquire due to tenuous atmospheric conditions; therefore, we must depend on modelling techniques to comprehend the behaviour of these magnetic fields. A commonly applied approach is the extrapolation method, which models the coronal magnetic field by employing photospheric magnetic field observations as boundary conditions. The simplest among these is the potential field assumption to the coronal field and is under the assumption of zero electric current. Although computationally less expensive, potential field is not appropriate for capturing stored magnetic energy configurations. Linear Force Free Fields (LFFF) is an alternative extrapolation model that incorporates a constant twist in the field. As twist varies spatially in the active region (AR), this approach also does not accurately depict field lines. To tackle this, Non-Linear Force Free Fields (NLFFF) have been used, incorporating spatially varying twist into the AR. The NLFFF is an appropriate model that reproduces more accurately the sheared and twisted magnetic structures found in the majority of the active regions during the pre-eruptive phase. Nonetheless, static extrapolation methods can solely provide a fixed depiction of field lines and do not account for their dynamic evolution. Temporal changes are crucial when examining time-related phenomena such as twisting, eruption, and energy accumulation. To address these constraints, time-varying Magnetohydrodynamics (MHD) modelling methods have been developed. In this approach, time-dependent MHD equations are solved, allowing for the capture of magnetic stress build up and the gradual evolution of flux ropes. They are classified intothree different groups with increasing levels of complexity and realism: the magneto frictional(MF) model, zero-β MHD and full MHD.

In this work, we employed a time-dependent data-driven magneto frictional (TMF) model to simulate the evolution of the magnetic field in the AR 13500. The AR produced a fast CME associated with an M9.8 class flare at 19:50 UT on 28 November 2023. Given that the energy storage duration is 2-3 days, the simulation commenced at 12:00 UT on November 25. Instead of driving with a magnetic field, the initial field is driven by electric fields that are derived from the time-sequence vector magnetic field observations of the photosphere. The electric fields are energized by including a non-inductive component by an ad hoc parameter that controls the twist in the field lines. The input energy injection from the electric field is constrained by the observed Poynting flux. To explore the sensitivity of the model to this twisting parameter, we performed two simulation runs using different values of the ad hoc parameter. The initial magnetic configuration evolved into a twisted sigmoidal structure and later into a complex nature, indicating the onset of eruption. The time evolution of helicity and energy injection computed showed gradual buildup over time, indicating significant accumulation in the AR by the time of eruption. The model is then validated with EUV observations obtained from the Atmospheric Imaging Assembly (AIA) instrument onboard the Solar Dynamics Observatory (SDO). The proxy emission maps generated from the simulated field showed striking morphological similarities with the observations. Hence, we were successfully able to simulate the magnetic evolution of the active region, reproducing the formation and eruption of twisted flux rope. Our result showed that the TMF model can be used to reproduce the slow and steady evolution of field lines and can serve as an initial condition for full MHD simulations.

Self-Similar Analysis of Shock Waves in Jupiter's Magnetosphere

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ABSTRACT

Solar winds from the Sun interact with planetary magnetospheres, causing shock waves. We have studied the dynamics of these shocks using Lie group theoretic methods, obtaining similarity solutions and shock paths. It is interesting to note how the wave dynamics evolve with time. We have done an extensive parametric analysis that considers physical parameters. Their roles are explored both qualitatively and quantitatively. Theoretical results are supported with detailed graphical interpretation. The medium around this phenomenon is dusty plasma. It comprises charged dust particles, ions, electrons, etc. They are prevalent outside of Earth as well. In this work, we aim to study the plasma environment outside of Jupiter. Specifically, the shock waves that form when solar wind interacts with Jupiter's magnetosphere. We also draw comparisons from shock waves in Earth's and Saturn's magnetospheres. The methodology comprises Lie groups and self-similarity analysis. The research problem is defined using a collisionless multi-fluid plasma system, which is represented by partial differential equations(PDEs) and converted into ordinary differential equations(ODEs) using self-similarity transformations. The results highlight the dynamics of the flow variables, which help us understand the behavior of shocks in dusty plasma around Jupiter. The research concludes that due to the dominance of the thermal effect, the extraterrestrial shock follows an exponential path and decays with no steep fronts.

Role of Thermal States and Interactions of CMEs in Modulating Their Geo effectiveness

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ABSTRACT

The thermodynamic evolution of coronal mass ejections (CMEs) remains a critical yet relatively underexplored aspect of heliophysics. Limited studies have addressed how a CME's thermal state is linked to its dynamic evolution and geo effectiveness. In this work, we adopt both case-specific and statistical approaches to investigate CME thermal states and associated space weather impacts. Notably, a CME's thermal state can evolve significantly through interactions with the ambient solar wind, and even more dramatically during CME-CME interactions. We demonstrate these thermal transitions through case studies of both slow and fast CMEs, and with a detailed analysis of six successive Earth-directed CMEs that culminated in the most intense geomagnetic storm of the past two decades on 10-11 May 2024. We also perform a statistical analysis of magnetic ejecta across Solar Cycles 23–25 to understand their thermal and other plasma characteristics at 1 AU. The study shows that CMEs experiencing heating have a higher potential to drive stronger storms than CMEs in a heat-release state near the Earth. Our methodology integrates 3D kinematic reconstructions using the Graduated Cylindrical Shell (GCS) model and thermal diagnostics via the Flux Rope Internal State (FRIS) model, supported by white-light CME observations and in situ measurements. The study underscores that additional information on the thermodynamics of CMEs and CME-CME interactions can complement the state-of-the-art techniques estimating CME arrival time and its potential for geo effectiveness.

Physics-Based Flare Forecasting: Role of Winding Flux and Persistent PILs Evolution During Precursor Phase of the Intense Solar Flares

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ABSTRACT

Solar flares are the largest magnetic explosions on the Sun. However, accurate prediction of solar flares remains a major challenge in the heliophysics and space weather research. Despite significant advances in observational capabilities and data-driven modeling, pinpointing the exact onset time and location of the flares remains elusive, largely due to the complex and dynamic nature of the solar magnetic fields. Understanding the physical precursors that lead to the initiation of flares is critical for improving flare forecasting capabilities. In this work, we present a detailed analysis of two highly flare-productive active regions, AR13664 and AR13842, during Solar Cycle 25, based on SDO/HMI vector magnetograms and SDO/AIA EUV observations. We compute key magnetic topological quantities, including magnetic helicity, winding flux, and Poynting flux, using ARTop and DAVE4VM-based velocity fields. Our results reveal that the magnetic winding flux, particularly its emergence component, consistently exhibits a significant enhancement a few tens of minutes prior to the X-class flares. To isolate topologically significant regions, we develop a novel masking approach combining the vertical magnetic field and winding fluxthresholds to identify persistent polarity inversion lines (PILs). These masked PILs are temporally binned, showing a peak 1–3 hours prior to the flare maxima, suggesting their role as pre-flare indicators in the initiation of solar flares. The temporal evolution of the reappearance of the PILs positively correlated with the possible source region of the solar flares. Our approach demonstrates that combining winding flux and persistent PIL detection can reliably isolate flare-triggering regions, providing both spatial and temporal pre-flare signatures. The integration of these topologically rooted parameters into next-generation machine learning models holds the potential to bridge the gap between predictive performance and physical understanding in flare forecasting.

Characterizing Severe Geomagnetic Storms and Their Magnetospheric Drivers in Solar Cycle 23 & 24

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ABSTRACT

During solar cycle 23, the interplanetary drivers of severe geomagnetic storms and their solar cycle dependence were systematically analyzed. All severe geomagnetic storms observed in this period coincided with prolonged intervals of southward-directed interplanetary magnetic fields (IMF) in GSM coordinates, indicating that magnetic reconnection between the southward IMF and magnetopause fields was the primary mechanism triggering these storms. This study investigates key interplanetary parameters interplanetary magnetic field (B), its south-north component (Bz), solar wind speed (Vsw), density (Dsw), and temperature (Tsw) alongside magnetospheric indices such as Kp, Ap, SYM-H, sunspot number (SSN), and solar radio flux (F10.7), utilizing OMNI data spanning the solar cycle.

Event selection was based on the equatorial SYM-H index to identify severe storms (Dst ≤ -150 nT). Our analysis reveals that intense southward Bz and consequent geomagnetic storms are predominantly driven by specific interplanetary structures: magnetic clouds driving fast shocks (sMC) and sheath fields (Sh), each responsible for 30.4% of the storms; combined sheath and magnetic cloud fields (Sh+MC) causing 17.4%; non-magnetic clouds (non-MC) at 17.4%; and complex structures at 4.3%. Together, these four structures account for approximately 75% of all severe storms during the cycle.

Additional contributors include heliospheric current sheets, high-speed stream Alfvé'n waves, non-magnetic cloud ICMEs, and complex interacting ICME and shock structures. Temporal analysis shows that severe storms during the rising phase are primarily driven by sMCs and sheaths, while sheath fields dominate at solar maximum,

followed by Sh+MCs and sMCs. During the declining phase, sMCs, sheaths, and CIR fields are the main drivers.

Correlation analysis highlights the strongest relationships between Dst peak and peak interplanetary magnetic field parameters, with correlation coefficients of 0.64 (Dstpeak vs. IMFBpeak) and 0.62 (Dstpeak vs. IMFBzpeak). Moderate correlations exist between Dstpeak and solar wind temperature (CC = 0.54), and solar wind density (CC = 0.41). Conversely, correlations with solar activity indices are weaker, with SSN (CC = 0.21) and F10.7 flux (CC = 0.35).

Comparative Analyses of Soliton Signatures in Geomagnetic Storm Phases during Solar Cycles 24 –25 Using Cluster II Data

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ABSTRACT

Solitary structures, commonly known as solitons, are a class of nonlinear plasma waves that are abundantly found in the near Earth plasmas and planetary magnetospheres. They are nonlinear, localized plasma waves that maintain their shape and velocity over time and distance .While their occurrence in various space plasma environments has been extensively reported, theirobservation during geomagnetic storms, large-scale disturbances driven by interactions between the solar wind and Earth's magnetosphere, remains limited. In this study, we present a comparative analysis of soliton signatures across the three distinct phases (initial, main, and recovery) of geomagnetic storms during solar cycles 24 and 25. Utilizing high-resolution in-situ measurements from the Cluster II mission, we systematically investigate the conditions conducive to soliton formation and their evolution during storm-time dynamics.

Multi-Application Solar Telescope – Instruments and capabilities

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ABSTRACT

MAST is a 50 cm off-axis telescope installed on the Island site of Udaipur Solar Observatory (USO), India. The telescope is capable of providing a diffraction limited resolution of 0.2 arc-sec at 617.3 nm. During moderate seeing conditions, with the help of the installed AO system, we can obtain diffraction limited observations. The MAST is currently used for observations in different wavelength bands, specifically covering lines originated in the photospheric and chromospheric layers. Simultaneous G-band (430.5nm, 1nm FWHM) and H-alpha line center (656.3 nm, 0.05nm FWHM) observations in high cadence can be carried out with those filters during flares and other solar activities. Another instrument which is installed with MAST is a narrow-band imager which uses two electrically tunable solid state Fabry-Perot etalons. This instrument can provide simultaneous spectral imaging in a photospheric (FeI 617.3nm,0.085 nm FWHM) and chromospheric (CaII 854.2 nm, 0.0175 nm FWHM) spectral lines. These observations are used for understanding the photospheric-chromospheric coupling during various dynamical solar phenomena. A polarimeter is also attached, which is being calibrated and currently being tested for both photospheric and chromospheric magnetic field measurements. In this presentation I will cover more details about the instrument, will go through some of the recent results, and also an update on polarimeter calibration.

Confined vs. Eruptive Solar Flares: A Thermal and Compositional Diagnostic Study with Ad itya-L1/SoLEXS

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ABSTRACT

Solar flares and coronal mass ejections (CMEs) are the Sun's most energetic eruptions, but what determines whether a flare is "confined" or "eruptive" remains unclear. A key factor is how magnetic energy is divided among plasma heating, particle acceleration, and eruption kinetic energy.

In this study, we investigate by comparing the thermal evolution of eruptive and confined flares using high-cadence soft X-ray (SXR) spectral data from the Solar Low-energy X-ray Spectrometer (SoLEXS) aboard Aditya-L1. We analyze a sample of flares spanning different GOES classes (C, M, and X), including both CME-associated (eruptive) and non-eruptive (confined) events. For each flare, we perform time -resolved spectroscopic analysis to derive key plasma parameters: temperature (T), emission measure (EM), and elemental abundances. By examining the temporal evolution of T and EM across flare phases, we aim to identify systematic differences in heating, cooling of the two event types. We hypothesize that the energy required to initiate a CME may result in observable differences in the peak thermal properties or decay timescales of the flare plasma.

Furthermore, we investigate whether the large-scale magnetic restructuring in eruptive events leads to distinct elemental abundance signatures, potentially indicating different plasma source regions or supply mechanisms compared to their confined counterparts. This work provides new observational constraints on the thermodynamics of solar flares and offers insights into the fundamental processes governing the flare–CME relationship.

Characterizing Small-Scale Transient Chromospheric Brightening Using Data from MAST and SDO

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ABSTRACT

The solar atmosphere is dominated by intense magnetic activities, where strong heating events occur throughout the different layers of the atmosphere. Small-scale transient events, such as Ellerman bombs, UV Bursts, are thought to play a crucial role in transferring energy from the Sun's lower atmosphere to its outer layers. When observed in Ca II filters, the solar chromosphere constantly shows several small-scale compact brightening events in the sunspot plage regions, which are not very well understood. Here, we present an analysis of narrow-band images of Ca II 8542 Å data observed by the Multi Application Solar Telescope (MAST). These observations are complemented by multi-channel data from the Atmospheric Imaging Assembly (AIA) and Helioseismic and Magnetic Imager (HMI), both onboard the Solar Dynamics Observatory (SDO). We detected some of these brightening events using our algorithm based on the intensity of their surrounding. We detected 62 bright points from the AIA 1700 Å passband and characterized them with different factors such as occurrence, lifetime, area, and magnetic field. We used time-lag analysis to study their origin and evolution. We found that most of these bright points have a lifetime of less than 6 minutes and are associated with flux cancellation/emergence. We found that more than 50% of these brightenings reach the transition region temperature during their lifetime. 24% show their signature in MAST Ca II 8542 Å observations. We also studied their spatial distribution around the active region to find any possible relation with their occurrence. In this presentation, we will present a detailed statistical investigation of such compact brightenings with their origin and thermal evolution.

Multi Wavelength Study of Solar Polar Coronal Hole Jets

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ABSTRACT

Solar jets are transient events, ubiquitous across the solar atmosphere. They are thought to play a crucial role in coronal heating and transfer of mass and energy through different atmospheric layers, including the solar wind. Small-scale jets are generally classified into two types: (i) Standard jets, characterized by inverted Y-shaped structures, and (ii) Blow-out jets, which have broader spires and are often linked to mini-filament eruptions.

In this work, we analyzed a standard polar coronal hole jet using high-resolution data from the High Resolution Imager (HRI) onboard Solar Orbiter (SolO). Our observations revealed a filament-like structure interacting with the jet, and we tracked the evolution of the jet and the filament material. The jet was also visible in the Atmospheric Imaging Assembly (AIA) cooler temperature channels and in the imaging data from Interface Region Imaging Spectrograph (IRIS), indicating the presence of both cooler and hotter plasma. The jet's energy is in the nanoflare range, typically associated with jets reaching heights of up to 5 Mm, but in this case, the jet extended up to 30 Mm above the limb. We observed a transverse motion in the jet, which may be a signature of multiple successive reconnections.

Low-Latitude Aurora Observations from the Indian Region

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ABSTRACT

The interaction of solar-origin plasma particles and electromagnetic fields with Earth's magnetic field gives rise to various space weather phenomena, such as geomagnetic storms, substorms, and visible auroras. Substorms are dynamic electrodynamic events within the coupled magnetosphere–ionosphere system, typically manifesting as vivid auroral displays within a latitudinal band between approximately 60° and 75° in both hemispheres.These auroral emissions occur when energetic electrons and protons, guided by magnetic field lines, precipitate into Earth's upper atmosphere, exciting atmospheric particles and producing characteristic colorful light displays. The auroras are usually confined to high latitudes, but the past reports and recent observations have challenged this belief.Recently, aurora was observed by the all-sky camera at Hanle, Ladakh, India (33°14'N geographic latitude),sparking considerable interest in the scientific community. This presentation provides an overview of auroral activity, particularly at low latitudes. It includes a historical review of auroral sightings across the Indian region during the space age and examines whether such auroral events can genuinely extend to Indian latitudes.

Onset and evolution of solar fl ares: A multi -wavelength perspective

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ABSTRACT

The contemporary multi-wavelength observations have immensely improved our understanding of the various physical processes occurring in different atmospheric layers of the Sun during a solar flare. The formation of parallel ribbons and associated overlying large post-flare arcades are important signatures which form the basis for the standard 2D model of solar flares. The standard flare model recognizes the flare's impulsive and intense brightening as consequence of the large-scale magnetic reconnection in a vertical current sheet in the solar corona. In this seminar, I will summarize multi-wavelength observations of solar flares and flare-associated phenomena, outlining the scope and limitations of the standard flare model.The observations of circular ribbon flares (CRF), a morphologically distinct class of solar flares, will also be discussed. In complex manifestations of CRF, the primary event may also exhibit the presence of parallel ribbons, remote ribbons, and jet activity. The typical morphological features and other complexities of such events are discussed in view of the topological structure of a 3D null point. These observations also enable us to explore analogies between the circumstances that govern the onset of jets, confined flares, or CMEs.

Rotational characteristics of Solar Corona using SDO/AIA SFD images at 193 E

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ABSTRACT

Coronal heating in the solar atmosphere remains one of the most challenging problems in solar physics. Solar rotation plays a significant role in coronal expansion by influencing the interaction between fast and slow solar wind streams. It also drives various solar activities and can be measured using methods such as tracer tracking across the solar disk, solar spectroscopy, and flux modulation techniques involving radio waves, X-rays, and ultraviolet radiation.The Solar Dynamics Observatory (SDO), a NASA space mission, was launched to study variations in the Sun's magnetic behavior. Observations from SDO enhance our ability to forecast solar variations that affect space weather.In this study, the rotational behavior of the solar corona is analyzed using full-disk solar images at 193 Å captured by the AIA instrument onboard SDO over the period 2011–2025. Latitudinal bins separated by 10° each are selected on these images, spanning from 80°N to 80°S to fetch the integrated flux value from each image. This will form annual time series of integrated flux of each such latitudes from daily solar full-disk images (one per day) of each year over the period of study. The modulation in flux in the time series may have periodic components. The period of those components present in the time series due to solar rotation are estimated using the statistical tool such as Lomb-ScarglePeriodogram (LSP), which reveals temporal and spatial variations. The coronal rotation period is determined as a function of latitude, showing both rigid and differential rotation at different phases of the solar cycle. A

differential equation characterizing latitudinal variation in coronal rotation for the study period is also derived. Detailed results will be presented in the paper.

J- and U-Type Solar Radio Bursts as Diagnostics of Coronal Magnetic Topology and Electron Propagation

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ABSTRACT

Solar radio bursts (SRBs) offer valuable insights into energetic electron propagation and coronal magnetic field structures. Among these, J- and U-type bursts are particularly significant for studying electron dynamics along closed magnetic loops. While type III bursts, associated with open field lines, have been extensively studied, J- and U-bursts remain comparatively less understood. This study focuses on investigating J- and U-type bursts observed during Solar Cycle 25 with characterisation of solar accelerated electron beams, using high-resolution spectrograms from the e-CALLISTO network. Through this research, we aim to address how J- and U-bursts map to coronal magnetic field structures, what determines their morphological transitions, distinguishing J- and U-type SRBs, and how local plasma density variations and acceleration mechanisms contribute to their formation. A total 37 events (J-type: 17; U-type: 20) have been identified. Events were screened based on spectral morphology and frequency drift characteristics. The observations from different instruments from the network allowed us to assess whether loop geometries or magnetic field asymmetries govern the observed burst morphology. Detailed measurements, including drift rates and burst durations, were performed, and electron beam velocities

were estimated using standard coronal density models. To investigate magnetic field connectivity, potential field source surface (PFSS) extrapolations from SDO/HMI data were employed, complemented by EUV imaging from SDO/AIA to identify corresponding active regions.In this study, we found, type U bursts are in transient large-scale structures as well as in configurations that are stable over large times, as compared to type J bursts. This study also explores that U-type bursts are predominantly associated with shorter, lower-lying closed magnetic loops, while J-type bursts correspond to longer or partially open field lines, with distinct thresholds in loop length and apex height governing the morphological transition. This study enhances our understanding of solar radio bursts by linking their shapes to coronal magnetic structures, offering valuable clues for probing electron acceleration and improving space weather diagnostics.

SPARSH: A Solar Probe Array for Real -time Space Hazards

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ABSTRACT:

The increasing frequency and complexity of solar eruptive events, particularly Coronal Mass Ejections (CMEs), demand advanced observational strategies to enhance early warning systems and ensure the resilience of space-based technologies. While missions such as Aditya-L1 offer continuous observations from the L1 Lagrange point, their single-line perspective limits the geometric accuracy required for precise CME trajectory reconstruction and real-time forecasting. To address this limitation, I propose SPARSH (Solar Probe Array for Real-time Space Hazards)a novel architecture deploying AI-enabled micro-probes in coordinated solar orbits to enable triangulated CME detection and solar wind profiling.SPARSH introduces a distributed observational framework in which a constellation of ultra-lightweight probes tethered or autonomously maneuveredoperate in synergy with a primary spacecraft. These probes are strategically positioned to provide angular diversity in observing eruptive solar events. Each micro probe is embedded with onboard artificial intelligence; including convolutional neural networks (CNNs), to autonomously identify CME signatures, classify solar wind anomalies, and filter high-priority data for transmission. This architecture allows for low-latency, distributed data processing, overcoming bandwidth and power constraints typically associated with deep-space missions.Initial simulations of the orbital configuration confirm that multi-point triangulation improves CME directionality estimation and temporal resolution, reducing forecasting ambiguity. The system is designed to adaptively learn from data streams, offering a scalable platform for long-term solar monitoring and real-time hazard assessment. By integrating heliophysics, orbital mechanics, and embedded AI, SPARSH represents a forward-looking model for enhancing solar-terrestrial space weather prediction. SPARSH aims to bridge current observational gaps and empower predictive heliophysics through cost-effective, AI-enhanced technology.

Long-term Modulation in Cosmic rays due to solar activity in Solar Cycles 23 -24

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ABSTRACT

A major trend in the solar magnetic field that began at the end of solar cycle 22 continues to be observed. The main characteristics of the solar magnetic field and the associated heliospheric field are crucial to the modulation of cosmic rays. Long-period variations of cosmic rays in cycles 23–24 show a weakening of the solar magnetic field. A comparison of these variations and those of the previous cycles reveals features of the modulation in the last two cycles. It is also found that velocity of solar wind (Vsw) and turbulence and strength of the interplanetary magnetic field were positive correlated and, inverse correlated with count rate of cosmic ray intensity.

Study of Solar Coronal Rotation using Nobeyama Radio Heliograph at 17 GHz

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ABSTRACT

Solar rotation is one of the vital characteristics of the Sun as most of the solar activitiesare contingent with solar rotation. The rotation of the Sun varies as the function of altitude as well as latitude. Information about the rotation of the Sun is not sufficient as necessary to forecast the solar activity as well as the space weather. Solar rotation can be obtained through the methods as; tracking of tracers on solar surface, spectral analysis, helioseismology and flux modulation. The flux modulation traces the passage of radio feature over the solar disc. Annual time series generated from solar full disk image obtained from the Nobeyama radio-heliograph at 17 GHz for the period extends from year 2010 to 2020. Latitudinal bins formed on equally separated regions (5^0 each) on such SFD images (one image per day) extended from 45^0S to 45^0N. The periodic components present in the time series can be estimated by statistical methods such as autocorrelation, Fast Fourier transform, wavelet analysis and/ or Lomb Scargleperiodogram. In the present work flux modulation method is used to obtain solar rotation and LSP is used to estimate periodic component present in the time series. Rotation rate obtained from such statistical analysis varies as the function of latitude. Rotation rate is plotted against sin square of latitude for both the hemispheres and a linear trend line $(\ )\quad A\quad B\sin^2(\ )$ is fitted with rotation profile. The coefficients representing equatorial rotation (A) and differential rotation at low latitudes (B) are compared with annually averaged sunspot numbers. The result shows rigid rotation as well as differential rotation of solar corona in different epoch of study period. This

variation in solar coronal rotation may be linked with the solar activity cycle (11 year sunspot cycle). Solar coronal rotation also shows in phase and out phase relation with solar activity cycle. Detail result would be presented in the paper.

Relationship of Global EUV Waves with Solar Coronal Holes and Coronal Mass Ejections during year 2010 to 2016

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ABSTRACT

We have studied the relationship of global EUV waves observed by SDO, solar coronal holes and coronal mass ejections (CMEs) observed by LASCO between 2010 to 2016. The global EUV waves data used here were published by Long, et. al.(2017) and CMEs data were taken from the CDAW web site and coronal hole data taken from lmsal. Total number of events reported by Long et al. (2017) are 362 out of which 164 events are associated with EUV waves. On studying 164 EUV waves events we found that there are only 49 events those have proper flare class, flare location, and the active region. The average distance between associated coronal hole (CH) boundary and flare location is 41 degree for the events those are associated with EUV waves. Out of 164 EUV waves 124 are associated with CMEs. We find that the global EUV waves median speed is poorly correlated with the linear speed of CMEs. Earlier, We have discussed various results obtained in the present analysis in view of recent solar heliophysics findings as discussed by Verma and Mittal (2019).

Predicted maxima of solar cycle -25 and Geomagnetic storms

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Less number of solar activity occurred during the last cycle -24. From year 2014 to 2018, sunspot numbers declined, reflecting the minimum phase of the solar cycle. from year 2019, the numbers of sun spots began rising again, indicating a new solar cycle. Occurrence of sun spots in this current cycle is more from the beginning compare to last cycle. The predicted value of sun spots is (150) for year 2025, suggests a peak in solar activity. Cycle Pattern follow as Minimum activity occurred around year 2018, Rising trend toward year 2025, consistent with Solar Cycle 25 expectations. The polynomial regression has $R^2 > 0.95$, indicating a good model fit. Extrapolation aligns with physical solar models. Increased sunspot activity can affect satellites, power grids, GPS, and climate models. Also examines the solar flare and solar wind plasma parameters and its modulations in the time slot of present cycle-25. Geomagnetic storms were less because solar activities are very less during the cycle-24.

Observational study of reoccuring EUV wave event on 2021 Dec 06

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ABSTRACT

Here, we present the observations of two Extreme Ultraviolet (EUV) waves on 2021 December 06. First EUV wave occurred from NOAA active region (AR) 12898 at 05:35 UT. When this EUV wave reached to NOAA AR 12902 at 06:16 UT, it triggered the second EUV wave. These EUV waves were observed by the Atmospheric Imaging Assembly onboard the Solar Dynamics Observatory with high spatio-temporal resolution. The first EUV wave propagate with two different velocities, Fast component with of ~406 kms^{-1} and slower namely non-wave component with speed of ~181 kms^{-1} while second only non-wave component with speed of ~225 kms^{-1} .

Both the EUV waves are associated with CMEs. The second associated CME is not reported in LASCO. We interpret our observations in light of existing models.

Simulating the Magnetic Evolution of Active Region 12975 for the Formation and Eruption of Filament Structure

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ABSTRACT

Solar flares and coronal mass ejections (CMEs) are major explosive phenomena on the Sun that significantly affect space weather and space-based technologies. These events are triggered by the sudden release of magnetic energy gradually stored in the solar corona due to plasma motions on the solar surface. Understanding the processes of magnetic energy storage and release requires a detailed examination of magnetic field evolution.

In this study, we investigate the magnetic field evolution in active region (AR) 12975, which produced two successive CMEs associated with M-class flares over an eight-hour period on 28 March 2022. Using the DAVE4VM method, we estimate the magnetic helicity and energy injection rates to examine their role in the eruption. To model the evolution of the coronal magnetic field, we use a time-dependent magnetofrictional (TMF) approach, which simulates the formation and eruption of a filament and the associated flux rope. The simulation begins two days before the eruption to account for the energy buildup phase.

The time profiles of magnetic helicity and energy injection indicate a gradual accumulation, consistent with substantial magnetic energy storage before the eruptions. To validate the model, we compared the simulation results with EUV observations from the Atmospheric Imaging Assembly (AIA) aboard the Solar Dynamics Observatory (SDO). Our findings demonstrate that the TMF model successfully captures the slow

and continuous evolution of magnetic fields, accurately reproducing the formation and eruption of twisted structures driven by the buildup of magnetic energy and helicity within the observed timescales.

Spatio-Temporal Analysis of CME for Geo -effectiveness During May 2024

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ABSTRACT

This study analyzes geo-effectiveness using spatio-temporal resolution data from May 2024, which caused a significant geomagnetic storm in the current solar cycle, providing an opportunity for advancing machine learning-driven space weather research. We specifically utilize C2 and C3 coronagraph image sequences that capture CME evolution, with corresponding CME arrival times and Disturbance Storm Time (Dst) index values. Each sequence is classified as geo-effective (Dst ≤ -30, class 1) or non-geo-effective (Dst> -30, class 0). The approach involves decomposing sequences into frames, extracting spatial features using pretrained Convolutional Neural Network (CNN) models, and processing feature sequences with temporal models, including RNN, LSTM, GRU, Bidirectional LSTM/GRU, and their variants. This hybrid spatial-temporal architecture facilitates binary classification of geo-effectiveness, aiming to improve prediction accuracy and enhance understanding of solar-terrestrial interactions using recent data.

KodAI: A Deep-Learning based algorithm to extract filaments from Kodaikanal Solar Observatory Suncharts

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ABSTRACT

The long-term evolution of solar filaments, prominently observed in H-alpha, is closely related to the large-scale solar cycle, with their parameters tracing the solar surface magnetic fields and has been long thought to contribute to the polar fields of the next cycle. The Kodaikanal Solar Observatory (KoSO) hosts one of the longest reserves of archival data with the information of these features in the unique form of hand-drawn suncharts, where features like filaments, plages and sunspots are marked in different colours. In this study, we created a Convolutional Neural Network (CNN) based model for the extraction of these features from the entire period from 1954-1976 and present the preliminary results of the training. A comparison will be made with other extracted statistics and relevant solar cycle properties will be studied from the new filament time series.

Multi-Wavelength Analysis of the M4.5 -Class Solar Flare on 14 May 2024 from AR13682

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ABSTRACT

We present a comprehensive analysis of the M4.5-class solar flare that occurred on 14 May 2024, originating from Active Region AR13682 located at heliographic coordinates N17E72. Utilizing high-resolution imaging data from the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO), we analyzed the flare evolution in the 93 Å, 193 Å, and 304 Å EUV channels. Time series analysis was conducted using the AIA 304 Å channel, revealing the temporal evolution of chromospheric and transition region emission during the flare. The AIA 304 Å light curve was compared with soft X-ray flux data from the GOES satellite, showing a consistent timing of the flare peak and associated impulsive phase.

We further constructed height–time diagrams to track the motion of flare-related structures, enabling the estimation of flare ribbon separation velocities. These velocities provide insight into the magnetic reconnection rate and energy release mechanisms involved in the flare. Our multi-wavelength approach offers a detailed view of the dynamic processes during this moderate flare event and contributes to a broader understanding of flare energetics and magnetic field restructuring in active regions.

Probing the Sun under variable conditions using the Akatsuki radio science experiment

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ABSTRACT

In this study, we present a detailed investigation of the solar wind speeds and densities using the Doppler spectral width data derived from X-band radio occultation experiments conducted with JAXA's Akatsuki spacecraft during its superior conjunctions between 2016 and 2022. Our study demonstrates the utility of this technique for estimating both slow and fast solar wind velocities. While the observations in 2016 gave us the opportunity to study the ambient solar wind, the observations in 2022 allowed us to probe the region near coronal holes. Additionally, we also have estimated the electron densities and show how the region being probed impacts them. We also investigate the impact of electron density estimates on the accuracy of solar wind speed determinations, underscoring the need for improved electron density modeling to enhance the robustness of such measurements.

Solar Wind Soliton Formation and Its Link to Solar Transients: Insights from WIND Data

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ABSTRACT

Solitons or solitary waves represents a class of nonlinear plasma structures characterized by spatial localization and the ability to preserve their shape and amplitude during propagation [1]. Although frequently observed in near-Earth plasmas and planetary magnetospheres, direct observations of solitons in the solar wind remain relatively limited [2, 3, 4]. In this study, we investigate the plasma conditions conducive to soliton formation in the solar wind, with a particular focus on identifying potential correlations with solar transient events such as coronal mass ejections (CMEs), corotating interaction regions (CIRs), and solar flares utilizing high-resolution, high-cadence in-situ data from the WIND spacecraft.

MAG-RESNET: Magnetogram Super -Resolution using a Hybrid CNN - Transformer Network.

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Enhancing the resolution of low-quality solar magnetograms, such as those acquired by the Michelson Doppler Imager (MDI), is vital for deepening our understanding of solar magnetic activity and improving space weather forecasting. This paper proposes a novel deep learning architecture tailored for super-resolution reconstruction of historical magnetogram data. The model integrates Convolutional Neural Networks (CNNs) for efficient extraction of localized magnetic structures with Transformer-based modules that capture long-range spatial dependencies and global context. This hybrid framework is trained on a curated subset of nearly 4,000 image pairs, drawn from a comprehensive dataset comprising 10,464 aligned MDI-HMI magnetogram pairs, and will be validated on an independent set of 600 samples. Reconstruction performance will be quantitatively assessed using established evaluation metrics. By introducing a robust and scalable architecture for magnetogram resolution enhancement, this work aims to recover fine-scale magnetic field details from archival observations and support more accurate modeling of solar flare phenomena.

Forward Modeling of MHD Wave Signatures in the Solar Atmosphere

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ABSTRACT

Magnetohydrodynamic (MHD) waves are fundamental for understanding solar coronal heating mechanisms and energy transport processes in the solar atmosphere. Modern observations have revealed the ubiquitous presence of MHD waves in the solar corona.

In this work, we employ high-resolution numerical simulations using the MPI-AMRVAC code to model various MHD wave modes in closed coronal and transition region loops with realistic atmospheric stratification and magnetic field geometries. To bridge the gap between theoretical models and observational data, we utilize the FoMo forward modeling code to synthesize EUV emission and investigate the intensity, line width and Doppler shift signatures from our simulated plasma conditions. This approach enables direct comparison with current and upcoming observations from instruments such as Interface Region Imaging Spectrograph (IRIS), Solar Orbiter and Multi-slit Solar Explorer (MUSE), providing critical insights into wave damping mechanisms and line broadening effects. Our synthetic observables demonstrate how physics-based simulations can enhance the diagnostic capabilities of modern solar missions and support the development of them.

Study of failed filament eruptions from active region NOAA 11976

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ABSTRACT

Solar filaments are the dark elongated structure on the solar surface which are cooler and denser than the surrounding plasma. They stay in equilibrium due to the balance between the upward magnetic hoop force and downward magnetic tension. When this balance is disturbed, the filaments become unstable and can erupt out of the Sun. However, there are cases when even after their instability, the filaments fall back on to the surface of the Sun. Such cases are called failed eruptions. In present work, we analyzed eight cases of failed eruptions from a NOAA active region (AR) 11976. The upward speed of these filaments lies in the range 80 to 660 km/s and the downward speed in 65 to 370 km/s. Between these failed eruptions, there is one successful eruption at 22:30 UT, which erupted out with a speed of 600 km/s. After this successful eruption, the local magnetic configuration changed. As a result of this the failed eruptions changed the direction about 5 deg.

Extracting the true wave parameters of s low waves using SDO/AIA and SolO/EUI

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ABSTRACT

Coronal loops, the basic building blocks of active regions on the Sun, exhibit various kinds of dynamics, including waves and flows. We analyzed the open fan coronal loops that are rooted in the sunspot. The slow magneto-acoustic waves are exhibited in these open fan loops. In imaging observations, we get the projection effects. To remove the projection effect, we must determine the 3D coordinates and inclination angles of the projected feature. To achieve this, we implemented triangulation methods utilizing dual-vantage point observations from the Solar Dynamics Observatory/Atmospheric Imaging Assembly (SDO/AIA) and the Solar Orbiter/Extreme Ultraviolet Imager (SolO/EUI). Both these modern observatories capture images of the Sun at a good cadence and high resolution. We derived the time-period, true damping length, and true wave propagation speeds using the projection angle obtained from triangulation, and consequently, the temperature within a selected sample of loops. We obtain the dominant time-period, ~3 minutes, velocity, ~130 km/s, and temperature is approx. 0.84 MK. However, the damping length shows significant variation, ranging from 5 to 10 Mm. By investigating a large sample, we aim to investigate the dependence of temperature on the true damping length of propagating slow magnetoacoustic waves and compare the results with theoretical predictions.

Multi-Wavelength Perspective on the Evolution Of Magnetic Flux Complexity

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ABSTRACT
We present here direct observations of co-temporal appearance of complex magnetic flux system at solar chromospheric and transition level and its time evolution. The temporal evolution shows that the complex system of the magnetic flux tubes evolved to reduce the complexity. The appearance and relaxation of complexity of magnetic flux tubes at the chromospheric and transition levels can be considered as one of the processes which provide the energy toward coronal heating.

Multiwavelength Study of Wave Propagation in Sunspot Umbrae

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ABSTRACT

Magnetoacoustic waves (MAWs), particularly slow modes, are long-standing candidates for transporting and dissipating energy in the solar atmosphere, yet their height-dependent behavior in sunspot umbrae remains poorly constrained. We investigate the vertical structuring and propagation of slow MAWs using multi-wavelength observations from the Helioseismic and Magnetic Imager (HMI) and Atmospheric Imaging Assembly (AIA) onboard SDO for 20 nearly circular sunspots observed between 2012–2016.

Formation heights were estimated via cross-correlation of 3-minute oscillations between HMI continuum and AIA passbands. We find median formation heights of 356 km (1600 Å), 368 km (1700 Å), 858 km (304 Å), 1180 km (131 Å), and 1470 km (171 Å), with ultraviolet channels forming at stable low-altitude layers (250–500 km) and coronal channels extending to ~1.5 Mm with large variability.

Oscillation amplitudes increase with height, peaking near 700–900 km, while energy flux decreases sharply from ~3.3 kW m^{-2} at the photosphere to <10^{-3} W m^{-2} above 2 Mm. This flux shortfall is consistent with radiative damping and shock dissipation at low heights, and thermal conduction and viscosity in higher layers. Wave steepening is evident from the nonlinearity index, which peaks near the 1700 Å layer, declines in 304 Å, and rises again in 131 Å before falling in 171 Å, indicating multiple phases of nonlinear evolution and shock development.

Our results show that slow MAWs in sunspot umbrae undergo complex transformations with height, dissipating energy through shocks and nonlinear processes at distinct

layers. However, the remaining flux is insufficient to account fully for chromospheric heating, underscoring the need to identify complementary mechanisms.

Solar Radio Observations at USO -PRL: Progr ams and Initiatives for Solar Sciences and Space Weather Monitoring

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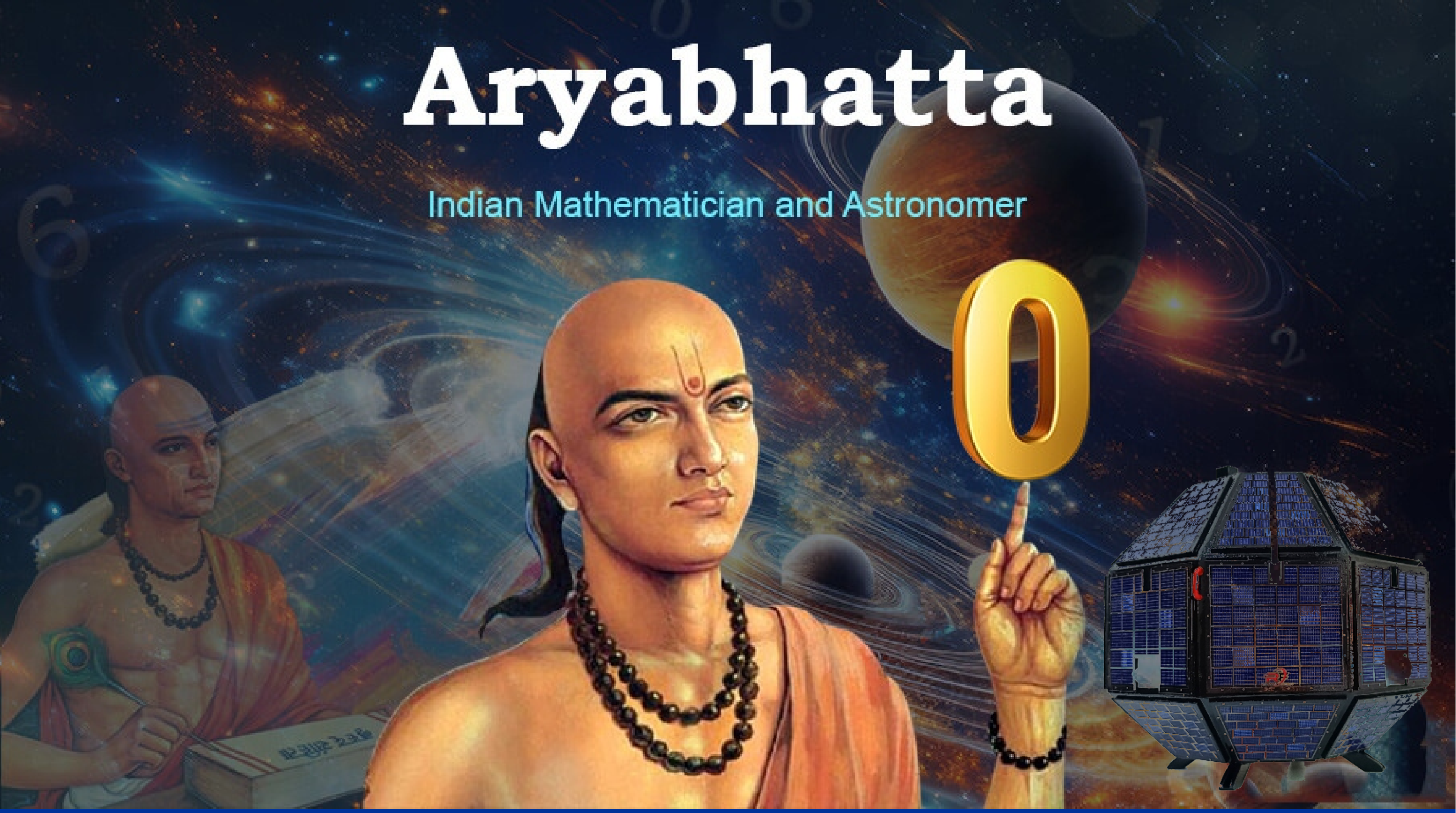
ABSTRACT
Solar radio observations are fundamental to probing the dynamic processes of the Sun's atmosphere, providing critical insights into energy release, particle acceleration, and transport associated with solar eruptive phenomena across diverse energy scales, including large flares and coronal mass ejections (CMEs) that directly influence space weather. Identifying Solar radio bursts—transient, energetic emissions triggered during eruptive solar events— serve as simple yet powerful diagnostic tools for exploring coronal phenomena. In particular, ground-based monitoring of the Sun is a powerful tool for real-time tracking of space weather events.
To address these scientific objectives and space weather monitoring requirements, USO-PRL initiated a solar radio observing program in October 2018. The first step was the installation of a Log-Periodic Dipole Antenna (LPDA) with a CALLISTO receiver covering the 45–870 MHz band. Since its commissioning, this facility has enabled routine monitoring of solar radio activity and has successfully recorded numerous solar radio burst events. Further, recognizing the importance of lower-frequency observations (10–80 MHz)—which probe the higher corona where CME-driven phenomena originate and evolve—an indigenous state-of-the-art Long Wavelength Array (LWA) antenna with an active balun front-end and up-converter was developed and installed in the H-plane in January 2024 with the CALLISTO back-end receiver. This system has already captured several prominent solar eruptions with promising signal-to-noise performance. Building on this success, a second LWA in the E-plane was installed in May 2025 to enable spectropolarimetric measurements. Characterization of both systems is ongoing, and together they will soon provide dual-plane polarization capability. In parallel, development of an indigenous FPGA-based

receiver is underway to achieve very high temporal and spectral resolution for spectrography and spectropolarimetry.

Looking ahead, USO-PRL has ambitious plans for both ground- and space-based instruments. These include the Wide-Band Solar Radio Spectrograph (WBSRS, 10 MHz–1.8 GHz), ARISO (Advanced Radio Instrumentation for Spectropolarimetric Observations, 50–500 MHz), and ARUN-SSW (Advanced Radio Telescope Udaipur Network for Solar and Space Weather Research, a GHz radio imaging instrument). Together, these initiatives aim to establish comprehensive capabilities for solar radio spectrography, spectropolarimetry, and imaging across metric to millimeter wavelengths, and complement India's maiden space-based solar mission, Aditya-L1.



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