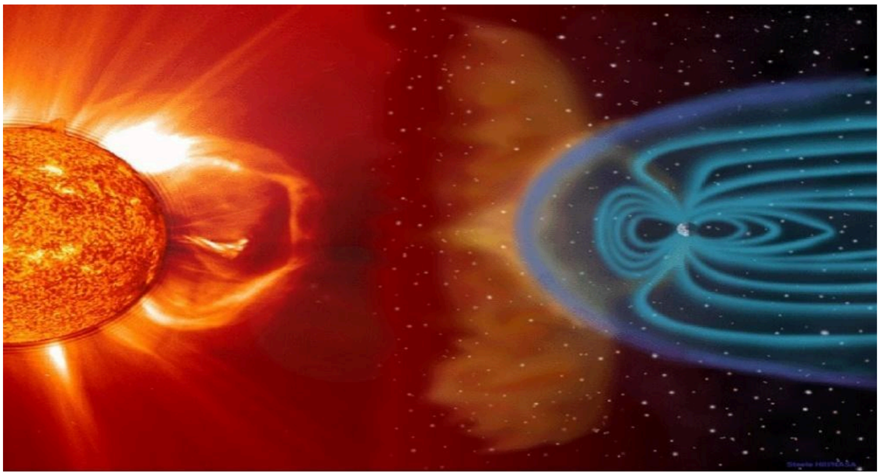
ASI Symposium 002:

Particle acceleration in the Sun and Heliosphere

Abstract Book



Organised by

PG and Research Department of Physics,

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Other Host:

Dr.C.Kathiravan, Indian Institute of Astrophysics, Bangalore

Dates : 16th -17th December 2024

ASI Symposium 002 :

Particle Acceleration in the Sun and Heliosphere (16-17 DEC 2024)

Arul Anandar College, Karumathur, Madurai.

Invited Talk			
S.No	**Name**	**Abstract Title**	**Affilation**
1	Dr.N. Gopalswamy	Solar Energetic Particles and Space Weather	NASA Goddard Space Flight Center
2	Dr.Anshu Kumari	Theory of particle acceleration by shocks and radio bursts	Physical Research Laboratory
3	Dr.Bhuwan Joshi	Probing multi-scale processes in solar flares through multi-wavelength observations	Physical Research Laboratory
4	Dr.M.Shanmugam	Particle detectors for space missions	Physical Research Laboratory
5	Dr.Rohith Sharma	Particle acceleration using X-ray and radio observations	IIT, Kanpur
6	Dr.Ramesh Chandra	Type II radio bursts and space weather phenomena	Kumaun University
7	Dr. K. Sasikumar Raja	Properties of energetic electrons inferred from solar radio bursts	Indian Institute of Astrophysics

8	Dr. K. P. Arunbabu	Galactic Cosmic Ray Observations for Space Weather Analysis	Cochin University of Science and Technology
Oral Presentation			
1	K.Sankarasubramanian	Particle Acceleration Studies with Aditya-L1	URSC, ISRO, Bangalore
2	K. P. Arunbabu	Signatures of Particle Acceleration within the Interplanetary Magnetic Flux Ropes	Cochin University of Science and Technology
3	Mahender Aroori	Statistical Study of Spatial and Temporal Characteristics of Solar Flares during Solar Cycle 24	Osmania University
4	Sruthi Mildred	Impact of two consecutive interplanetary shocks on plasma waves and particle dynamics in Earth's magnetosphere	Cochin University of Science and Technology
5	P. Vijayalakshmi	Association of an intense geomagnetic storm driven by a Radio-Loud coronal mass ejection (CME) and solar energetic particles (SEPs) with solar source	Arul Anandar College
6	K.Suresh	Studying Earth-Directed CME Deflection through Coronal Dimmings and Coronal Holes Analysis	PSR Engineering College, Sivakasi.

7	K. Mahalakshmi	Study of solar proton events in the rising phase of the solar cycle 25	United Institute of Technology, Coimbatore
8	Debi Prasad Choudhary	Thermal, Magnetic and Velocity Properties in Source Region of Solar Activity	California State University Northridge
9	S Prasanna Subramanian	Study of Earthquakes and their relation with solar activities	HKRH College, Uthamapalayam
10	Ritesh Sharma	A framework for modelling CME propagation	University of South Bihar
11	Pooja Devi	Prominence Eruption and Associated Loop Contraction	Kumaun University, Nainital
12	A. Kubera Raja	Major solar energetic particles and their relationship to associated flares and CMEs	Government College of Engineering, Bodinayakkanur
13	Shaik Sayuf	Estimation of Solar coronal magnetic field strength at meter wavelengths using augmented Gauribidanur RadioheliograPH (GRAPH)	Indian Institute of Astrophysics, Bangalore
14	Bendict Lawrance	Comparative Analysis of ICME Characteristics and Geoeffectiveness across Solar Cycles 23, 24 and 25	Gangseo University, Republic of Korea.

15	Suganya sundaramurthy	Estimating the coronal magnetic field strength via CME-driven shocks : A comprehensive evaluation of stand-off distance (SOD) method	Indian Institute of Astrophysics, Bangalore
16	Annalakshmi Muppudathi	Effect of Coronal Mass Ejections during Lunar Phases of Full moon day and New moon day	Periyar University, Salem.
17	S. Aswin Amirtha Raj	Trustworthiness of Sunspot's Magnetic Parameters in Predicting Coronal Mass Ejection Velocity	Arul Anandar College, Madurai.
18	Sushree Sangeeta Nayak	Studying flare ribbon dynamics using MHD simulation	Center for Space Plasma and Aeronomic Research, the University of Alabama, USA
19	M. Syed Ibrahim	Geo-effectiveness of non-active region interplanetary CMEs: initiation, propagation and near-Earth consequences	Sri Sai Ram Engineering College, Chennai.
20	G.Selvarani	Observations of radio bursts association with halo CMEs and M-class solar flares	Sri Meenakshi Government Arts College for Women, Madurai.
21	P.Pappa Kalaivani	Study on quick and delayed major SEPs based on the onset of type II radio bursts	Ultra College of Engineering & Technology, Madurai

22	A Mujiber Rahman	Radio analysis of solar activities associated with 25 Feb 2014 day event	HKRH College, Uthamapalayam
23	W.Hannah Blessy	Investigations on coronal mass ejections associated with flares and DH type II radio bursts of solar cycle 25 from January 2020 to December 2023	The American College, Madurai.

Poster Presentation			
1	K.Suresh	Examining CME-Driven Type II Radio Bursts: Insights from Multi-Instrument Observations from Solar Cycle 24	PSR Engineering College, Sivakasi
2	A. Ansar Ahamed	Study of a Halo CME and its Associated Activities observed on March 23, 2024	Hajee Karutha RowtherHowdia College, Uthamapalayam,
3	M.SyedIbrahim	Transit time of CME/shock associated with a major geo-effective CME in solar cycle 25	Sri Sai Ram Engineering College, Chennai
4	A. Alexander	Solar wind and climate change on the Earth	St. Joseph's College (Autonomous) Tiruchirappalli

5	Sunil Yadav	Discerning the contribution of small and large-scale magnetic fields on the X-ray flux of the Sun	IISER. Berhampur
6	RJ Anjana Shree	Temperature profile of Martian lower atmosphere and study its variation with seasons, through the day and with solar activity	Thiagarajar college, Madurai
7	R. Sindhan	On the Effective Rotational Temperature of Large Sunspot Umbra using $E^2\Pi - X^2\Sigma^+$ System of CaH Molecule	M.T.N. College, Madurai.
8	K.Subbu Ulaganatha Pandian	Investigation on Coronal Mass Ejections and Groups of Type III Radio Bursts during Solar cycle 23	Bharathiar University, Coimbatore
9	N.Yogeswaran	Investigations of changes in sunspot properties leading to coronal mass ejections	Arul Anandar College, Madurai.
10	Kere Ravi Arjun	Mars Perseverance Images to Validate Solar Far-Side Active Regions	IISER, Mohali
11	P.Jawahar Raja	Determining filament counts using H-alpha images of the Sun	Dr.N.G.P Arts and Science College, Coimbatore

12	J. Poojapriyatharsheni	Survey of H, He, and C radio recombination lines in the inner Galactic plane and the Cygnus-X region	Lady Doak College, Madurai
13	A. Raj krishnan	Investigations on coronal mass ejections of solar cycle 25 from January 2020 to December 2023	The American College, Madurai
14	M. Manivasuki	Relationship between CME activity, geomagnetic storms, and precipitation pattern during rainy seasons	Periyar University, Salem
15	C. Revathi	Forecasting seasonal climate trends during coronal mass ejections activity	Periyar University, Salem
16	P.P. Kannan	On the Effective Rotational Temperature of Large Sunspot Umbra using C2 Molecule	M.T.N. College, Madurai.
17	N. Venkatesh Bharathi	Computation of Radiative Transition Parameters of Dicarbon (C2) molecule in the high temperature atmosphere, S-stars and sunspots	M.T.N. College, Madurai.
18	Divya Kumari	Unraveling Solar Explosions: Insights into CME and ICME Dynamics through Multi-Wavelength Observations.	Jai Prakash University Chapra, Bihar

ASI Symposium – Program Schedule

16th - 18th December 2024

Day 1 – 16th December 2024 @ARUL ANANDAR COLLEGE

Time	Programme	Name of the Resource Person	Topic
9:15am-10:00 am	Inauguration & Overview of the programme	College management, SOC members Dr.A.Shanmugaraju, Arul Anandar College	
10:00am-10:30am	Review Talk 1	Dr.N.Gopalswamy, GSFC, NASA, USA	Observational Signatures of Particle Energization on the Sun
10:30am-10:50am	Invited Talk 1	Dr.Anshu Kumari, PRL, Ahmedabad.	Theory of particle acceleration by shocks and radio bursts
10:50am-11:30am	Tea Break		
11:30am-1:00pm	Contributed Talks		
1:00pm-2:00pm	Lunch Break		
2:00pm-2:30pm	Review Talk 2	Dr.Bhuwan Joshi, USO,PRL,Udaipur	Probing multi-scale processes in solar flares through multi-wavelength observations
2:30pm-2:50pm	Invited Talk 2	Dr.M.Shanmugam, PIDS, PRL, Ahmedabad	Particle detectors for space missions
2:50pm-4:15pm	Contributed Talks		
4:15pm-5:00pm	Tea Break / Poster Session		
6:15pm-7:00pm	Cultural Program		
7:00pm-8:00pm	Symposium Banquet		

Day 2 – 17th December 2024 @ARUL ANANDAR COLLEGE

Time	Programme	Name of the Resource Person	Topic
9:30am-9:45am	Review of 1st day programme	Dr.A.Shanmugaraju	
9:45am-10:15am	Review Talk 3	Dr.Rohith Sharma, IIT, Kanpur	Particle acceleration using X-ray and radio observations
10:15am-10:35am	Invited Talk 3	Dr.Ramesh Chandra, Kumaun University, Nainital	Type II radio bursts and space weather phenomena
10:35am-11.:5am	Tea Break & Poster Session		
11:35am-1:00pm	Contributed Talks		
1:00pm-2:00pm	Lunch Break		
2:00pm-2:30pm	Review Talk 4	Dr.Sasikumar Raja, IIA, Bangalore	Properties of energetic electrons inferred from solar radio bursts
2:30pm-2:50pm	Invited Talk 4	Dr.Arunbabu, Cochin University of Science & Tech, Kerala	Galactic Cosmic Ray Observations for Space Weather Analysis
2:50pm-4:00pm	Contributed Talks		
4:00pm-4:30pm	Tea break & Poster		
4:30pm-5:15pm	Panel Discussion & Closing session	Invited Speakers, SOC members and Participants	

Day 3 – 18th December 2024

Time	Programme
Full Day	Kodaikanal Observatory Visit for interested participants

Review/Invited Talks

Solar Energetic Particles and Space Weather

N. Gopalswamy

NASA Goddard Space Flight Center, Greenbelt, MD 20771

There are two main indicators of particle acceleration on the Sun and in the heliosphere: solar energetic particle (SEP) events and electromagnetic emissions such as radio bursts. The accelerated particles have energies significantly higher than thermal particles up to several orders of magnitude. While all radio emission from the Sun is due to electrons, energetic ions produce gamma-ray emission when the particles interact with the dense solar atmosphere. Particles are energized in flare reconnection and shocks driven by coronal mass ejections (CMEs) and propagate toward and away from the Sun. Particles propagating away from the Sun (SEPs) are detected by particle detectors on Earth and in space. Electrons flowing toward the Sun produce microwave bursts from cm to mm wavelengths. Some of these electrons also produce hard X-ray bursts and continuum emission extending to 100s of MeV. Understanding SEPs is important from both science and application points of view because they are poorly understood and present space weather hazard to humans and their technology in space. SEPs accompany energetic flares, coronal mass ejections (CMEs), and intense radio bursts, which help us understand particle properties such as intensity, spectra, and time evolution. This paper summarizes SEP properties and their space weather consequences.

Theory of particle acceleration by shocks and radio bursts

Anshu Kumari,

PRL, Ahmedabad

The main sources of solar energetic particles (SEPs) i.e charged particles such as protons, electrons, and heavy ions with energies ranging from tens of keV to GeV—are collisionless shocks driven by coronal mass ejections (CMEs) and solar flares. These particles are accelerated through distinct mechanisms: magnetic reconnection during solar flares accelerates particles impulsively, while CME-driven shocks accelerate particles more gradually as they propagate through the corona and interplanetary space.

In this talk, I will discuss the generation, transportation and acceleration mechanisms of SEPs through radio and particle observations. Early measurements revealed impulsive electron events linked to radio bursts, highlighting the association between electron streams and high-frequency emissions. Modern instruments have further confirmed this connection.

Probing multi-scale processes in solar flares through multi-wavelength observations

Bhuwan Joshi

Udaipur Solar Observatory, Physical Research Laboratory (USO-PRL), Udaipur 313001, India

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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 and subsequent intense particle acceleration in 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; this approach also enable us to explore analogies between the circumstances that govern the onset of jets, confined flares, or CMEs. Some intriguing observations of sub-A-class microflares, occurring outside the active regions, will also be briefly discussed.

Particle detectors for space missions

M. Shanmugam,

PIDS, PRL, Ahmedabad

In the early days, detectors such as Geiger-Müller counters, proportional counters and scintillation detectors were used for charged particle detection. These devices and their readout electronics were bulky and have limitations in their capabilities in terms of energy resolution and particle identification. In recent times, with the advancement of new technologies, there are several new technology detectors are employed for charge particle detection in space missions with improved spectral resolution and particle identification capabilities. Different types of detectors and detection techniques are employed based on the energy of the charged particle of interest. Space is a very hostile environment due to extreme temperature conditions, radiation environment and Vacuum. Developing instruments to work in such an environment is very challenging and needs proper planning & execution. In the talk, I will present the different types of charge particle detectors and techniques used for space missions including methods/techniques involved in identifying the charge particle type and their energy. Also, I will give a brief of the intricacies involved in developing instruments for space use.

Particle Acceleration Using X-ray and Radio Observations

Rohit Sharma[1], Sijie Yu[2], Marina Battaglia[3], Bin Chen[2], Yingjie Luo[4]

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[1]Space, Planetary, Astronomical Sciences and Engineering (SPASE), IIT Kanpur, India

[2]New Jersey Institute of Technology, Newark, USA

[3]University of Applied Sciences and Arts Northwestern Switzerland, Switzerland

[4]University of Glasgow, Scotland, U.K.

Particle acceleration in plasma is a fundamental process that occurs throughout the Universe. This phenomenon takes place in a variety of astrophysical environments, spanning different length scales, and emits across a broad range of the electromagnetic spectrum. Solar eruptive events, such as solar flares, jets, and coronal mass ejections, offer a valuable means of probing the underlying emission mechanisms like plasma emission, gyrosynchroton, electron-cyclotron maser etc.. and particle acceleration processes via observed energy distributions.

In the standard model, accelerated electrons in solar flares are believed to be ejected bidirectionally from the magnetic reconnection site. This results in upward-traveling electron beams that produce radio bursts and downward-moving beams that generate nonthermal X-ray emissions. As a result, it is expected that nonthermal X-rays and coherent radio emissions should be temporally correlated. However, the emission characteristics are influenced by local plasma conditions—such as magnetic fields, electron density, and pitch angle distribution—which often disrupt these temporal correlations, making the study of these phenomena particularly challenging. Additionally, magnetohydrodynamic (MHD) waves within the coronal loops can periodically alter the local magnetic field, leading to modulations and oscillations in the observed radio bursts.

In the last decade, combined X-ray imaging spectroscopy and radio imaging have yielded insights into the acceleration of electrons in various eruptive events. In this talk, I will summarise recent results from Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) and Spectrometer/Telescope for Imaging X-rays (STIX) combined with various ground-based radio telescopes.

Type II radio bursts and space weather phenomena

Ramesh Chandra

Department of Physics, Kumaun University, Nainital-263 001

In talk, we present a comprehensive statistical study between type II radio bursts from the metric (m) to the dekameric–hectometric (DH) domain and their associated solar and space weather phenomena, namely, solar flares, sunspot configurations, filament eruptions, coronal mass ejections (CMEs), their interplanetary counterparts (ICMEs) and shocks, in situ detected particles and geomagnetic storms. The m-only and m + DH radio signatures are identified from dynamic spectra provided by the ground-based RSTN stations distributed over the globe together with archived Wind/WAVES satellite data . We perform the temporal and spatial association between the radio emission and the listed above activity events during solar cycle 24, separately for the three sub-categories, metric, m + DH and DH-only type IIs. A quantitative assessment on the occurrence rates is presented as a function of the strength of the specific space weather phenomena: highest rates are obtained with CMEs, solar flares, filament eruptions, and sunspots configurations, whereas a much weaker relationship is found with ICMEs, IP shocks, energetic particles, and geomagnetic storms. The potential of the obtained rates to be used in empirical models for space weather forecasting is discussed.

Properties of energetic electrons inferred from solar radio bursts

K. Sasikumar Raja

Indian Institute of Astrophysics, Bangalore

Solar radio bursts are broadly classified into five types (I, II, III, IV, and V) based on their morphology and drift rates in the time-frequency (dynamic) spectrum. These bursts are often associated with solar transient emissions, such as solar flares, coronal mass ejections (CMEs), and jets. For instance, most type III bursts are associated with solar flares or other weak energy release events occurring in the solar corona. Type II bursts are linked to coronal shocks triggered by flares or CMEs. Moving type IV bursts are associated with the core of a CME. According to the standard flare or CSHKP model, after magnetic reconnection, particles traveling along the magnetic field lines in the radially outward direction generate radio emissions, while particles propagating downward are responsible for microwave emissions. In this talk, I will discuss the origin, propagation, and various properties of these particles and their role in generating solar radio bursts.

Galactic Cosmic Ray Observations for Space Weather Analysis

K. P. Arunbabu[a]
(on behalf of GRAPES-3 Collaboration)

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Kochi, Kerala, India
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Cosmic rays (CRs) are essential indicators of space weather phenomena, particularly in relation to Forbush decreases (FDs), which are sudden drops in CR intensity linked to solar events like coronal mass ejections (CMEs). This discussion will explore the complex relationship between FDs and CMEs, focusing on the mechanisms behind high-rigidity FDs and their connection to interplanetary shocks.

We will also examine the identification of FD precursors, which can be detected hours before the arrival of solar transients. These precursors provide critical data for forecasting space weather events, allowing for timely warnings about potential geomagnetic storms. The ability of these precursors to improve predictive models will be highlighted, showcasing their significance in enhancing the accuracy of space weather forecasts.

Additionally, we will delve into the importance of employing diffusion approximations to model cosmic ray behavior within the heliosphere. Understanding these diffusion processes is vital for refining predictions regarding the impact of solar wind dynamics on CR flux and, consequently, on space weather phenomena.

In conclusion, this talk will emphasize the interconnection of cosmic ray observations and space weather analysis, highlighting the importance of FDs and their precursors in improving predictive capabilities and ensuring effective monitoring of space weather.

Oral Presentation

Particle Acceleration Studies with Aditya-L1

K. Sankarasubramanian

URSC, ISRO, Bangalore

Aditya-L1 is India's first observatory class mission to study the Sun and its influence in the Heliosphere. Aditya-L1 carries seven payloads to study the dynamical nature of the Sun, source regions of the dynamics and its influence in the inter-planetary mission. Given the nature of measurements from Aditya-L1, particle acceleration at the source regions can be studied with imaging as well as spectroscopic payloads on-board. In this presentation, details of the capabilities of Aditya-L1 payloads which can be specifically used for particle accelerations studies will be covered. Few observations with those instruments on-board Aditya-L1 will be presented. The talk will also dwell on synergy between Aditya-L1 and other facilities (both ground and space) to bring in new observations related to particle acceleration mechanisms.

Signatures of Particle Acceleration within the Interplanetary Magnetic Flux Ropes

K. P. Arunbabu[a] **& A. Lara**[b]
(on behalf of HAWC Collaboration)

[a]School of Environmental Studies, Cochin University of Science and Technology, Kochi, Kerala, India
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The interaction of galactic cosmic rays (GCR) with the coronal mass ejections (CMEs) is an important area towards space weather analysis. Interplanetary magnetic flux ropes (MFRs) are a subclass of CMEs with well-defined magnetic topology. In this talk, we will discuss the signatures of particle acceleration that occur within the MFRs, which highlights the ability of these structures to modulate GCR flux and influence cosmic ray trajectory as they travel through the MFRs.

Key findings of our analysis indicate that MFRs can preferentially deflect charged particles, leading to significant increases in GCR flux along the axial direction of MFR. Factors such as the angle between the MFR and ambient magnetic fields, the presence of sheath regions, and the energy of the incident particles play significant roles in this anisotropic behaviour.

By synthesizing these insights, the talk aims to emphasize the implications for space weather predictions. Understanding the particle acceleration and trajectory within MFRs will contribute to a more comprehensive understanding of cosmic ray dynamics and their interactions with solar wind structures, which ultimately improve our ability to forecast space weather events that impact Earth and its surrounding environment.

Statistical Study of Spatial and Temporal Characteristics of Solar Flares during Solar Cycle 24

Mahender Aroori[1], **Sofia Kouser**[2]

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This study presents a comprehensive statistical analysis of solar flares observed during solar cycle 24 (i.e., from 10-12-2008 to 31-12-2019). A total of 15,349 solar flares were manually observed, categorized into five distinct classes based on their GOES X-ray intensity: A-class, B-class, C-class, M-class, and X-class. The analysis revealed that the majority of the flares were C-class (51.20%), comprising 7,859 events, followed by B-class with 6,313 flares (41.13%). M-class flares (4.71%) accounted for 723 events, while X-class, the most intense flares, were the least frequent with only 50 occurrences (0.33%). A-class flares, the weakest in terms of X-ray emission, numbered 404 (2.63%). In addition to the flare classifications, detailed information on the start time, peak time, and stop time of each flare was collected, along with their origination locations on the Sun. This comprehensive dataset enables a deeper understanding of the temporal and spatial distribution of solar flares, providing insights into the dynamics of solar activity and its variations throughout Solar Cycle 24.

Impact of two consecutive interplanetary shocks on plasma waves and particle dynamics in Earth's magnetosphere

Sruthi Mildred[1], **Ankush Bhaskar**[2], **K. P. Arunbabu**[1]

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[2]Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvananthapuram, Kerala, India

Interplanetary (IP) shocks provide a unique opportunity to understand the transient response of the magnetosphere. IP shocks compress the magnetosphere causing increasing plasma density and magnetic field strength in the magnetosphere, which can trigger or amplify wave activity. Plasma waves are generated during and after the arrival of IP shocks, which interact with the particles in the magnetosphere. Here we investigate the impact on plasma waves associated with two interplanetary (IP) shocks that impinged on the magnetosphere within an interval of ~25 h. The study utilizes high-precision fields and particle data from NASA's Van Allen Probes and MMS along with other spacecraft data within the magnetosphere and upstream solar wind. The radiation belt electron flux exhibited significant variations around the shock arrivals and propagation phase. The energy transfer during shock and wave interaction can accelerate particles to high energies, potentially resulting in high-energy particle events that impact satellite operations and astronaut safety. We discuss the observations and their impact in the context of current understanding.

Association of an intense geomagnetic storm driven by a Radio-Loud coronal mass ejection (CME) and solar energetic particles (SEPs) with solar source

P. Vijayalakshmi*, **A. Shanmugaraju**

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Geomagnetic storms on Earth and solar energetic particles (SEPs) accelerated by CME-driven shocks are the two major causes of solar activities. Therefore, it is necessary to study the association of such disturbances with the solar sources. In this study, we examined a radio-loud halo coronal mass ejection (CME) that produced SEPs (Ip > 10 MeV) and triggered intense geomagnetic storms. The eruption occurred on 21 April 2023 in solar active region (AR) 13283 near the disc center. The complex magnetic configuration in the AR 13283 at S22W11 caused an intensive M1.7 flare with a peak at 17:44 UT. The CME was observed to have a relatively high speed of 1284 km s^{-1} and an acceleration of approximately 28.1 m s^{-2} within the field of view (FOV) of the Large Angle Spectrometric Coronagraph. A Type II radio burst was detected in the frequency range of 14 MHz to 240 kHz from 18:06 UT to 22:26 UT on 21 April 2023 by the Wind/WAVES instrument. This event generated large magnetic turbulences in sheath region caused a major geo-magnetic storm (~ -213nT) at Earth's magnetosphere on 24 April 2023.

Studying Earth-Directed CME Deflection through Coronal Dimmings and Coronal Holes Analysis

<u>Suresh, K</u>., Dumbovic, M ., Chikunova, G ., Podladchikova, T., Veronig, A., Dissauer, K

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The connection between coronal dimmings and the deflection/rotation of coronal mass ejections (CMEs) is an area of active investigation in solar physics research. Coronal dimmings are frequently linked to the eruption of CMEs from the Sun. These dimmings occur due to the depletion or removal of plasma and magnetic fields in the regions where the CMEs originate. Regarding the deflection and rotation of CMEs, these phenomena can be influenced by various factors, including the configuration of the magnetic field in the solar corona. The interaction between the CME and the surrounding magnetic field can lead to deviations or rotational changes in the trajectory of the CME. To connect both the process, in this paper, we study the simultaneous observations of time evolution of dimmings and CMEs. The analysis involves examining the characteristics of dimmings, such as their location, area, and intensity, and comparing them with the deflection and rotation patterns of the associated CMEs. Our analysis involves considering the direction of CME propagation as determined through 3D reconstruction, the direction of dimming evolution, and the impact of CHIP force from CH to gather insights into the deflection or rotation of CMEs.

Study of solar proton events in the raising phase of the solar cycle 25

K. Mahalakshmi,

United Institute of Technology, Coimbatore

The four solar proton events on 25 February 2023, 23 April 2023, 23 March 2024, and 10 May 2024, which affected the Earth's environment, are studied during the rising phase of Solar Cycle 25. These events were associated with HALO coronal mass ejections (CMEs) and M- or X-class flares. The CMEs generated shock waves as they propagated through the interplanetary medium, causing geomagnetic storm events exceeding 100 nT in the near-Earth environment.

The initiation properties and propagation characteristics of these CMEs are analyzed using multiwavelength data. Additionally, the influence of shock waves on particle acceleration, along with the interplanetary consequences, is examined from the minimum to the maximum peak of Solar Cycle 25.

KEYWORDS: Solar Flare, CME, Proton events, Geomagnetic Storm

Thermal, Magnetic and Velocity Properties in Source Region of Solar Activity

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Because of their fast propagation and harmful effects to the near-Earth environment, flare forecasting is an important and active area of solar research. There is an extensive and increasing body of work dealing with the identification of physical processes and quantities which are flare precursors, together with the development of forecasting techniques based on them. Some progress has been made, so there is ample opportunity to investigate other relevant variables which could potentially increase the forecasting capabilities. While some studies consider the properties over the full active regions (AR) others have shown the importance of the polarity inversion line (MPIL) for flare initiation. In many models line-of-sight magnetic fields have been employed within limitations of the heliocentric angle and field strengths. Other methods are based on parameters derived from photospheric vector magnetograms (VMG) which are obtained through simple radiative transfer inversion techniques such as the Milne-Eddington (ME) approximation. In this presentation, we shall present the properties of the source regions of solar activity that produce the energetic particles.

Study of earthquakes and their relation with solar activities

S. Prasanna Subramanian,

HKRH College, Uthamapalayam, Tamilnadu India
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Earthquakes have a very strong geological effect that can affect people and the economy severely. It is a long-standing issue that the cause of the Earthquake is unknown. This study finds the cause of Earthquake and how Sun and solar activities are connected with the Earthquake. This study is searching the correlation between solar energetic particle (SEP) events which are detected in multiple energy channels and seismic activity, particularly earthquakes. Solar energetic particles, primarily protons and heavier ions emitted during solar flares and coronal mass ejections, have been shown to influence various geophysical processes. This research analyzes historical SEP data alongside earthquake records to identify potential patterns or anomalies that may suggest a relationship. Through Geological and space-based observation, statistical methods and data visualization techniques, we aim to elucidate the mechanisms by which solar activity could affect seismic events on Earth. The study will propose a new theory of Earthquake entitled 'Solar Theory of Earthquakes'. The findings contribute to the broader understanding of space weather impacts on terrestrial systems and may enhance predictive models for earthquake occurrences.

A framework for modelling CME propagation

Ritesh Sharma

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Coronal Mass Ejections (CMEs) are massive eruptions of plasma along with strong magnetic fields that have the potential to significantly affect Earth's magnetosphere, producing geomagnetic storms (GMSs) when high-energy particles in the plasma interact. Thus, it is essential to investigate the basic dynamics of CME evolution, propagation, and interaction with the ambient solar wind, to forecast space weather impacts, and reduce the CME hazards to contemporary infrastructure. In this work, we attempt to create a framework to model the CME propagation in the interplanetary medium, and its subsequent interaction with Earth's magnetosphere. This work is motivated by the increasing demand for safeguarding the vast technological infrastructures such as power grids, navigation systems, and satellite operations ground-based and satellite technologies from GMSs caused by CMEs that endanger by advancing the current understanding in space weather studies.

Prominence Eruption and Associated Loop Contraction

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We present a prominence eruption of 02 March 2015 associated with a GOES M3.7 class flare. The event is observed by Atmospheric Imaging Assembly (AIA) and the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI). Both AIA and RHESSI observations support the standard model of eruptive flares. The source region is a decaying bipolar active region where magnetic flux cancellation is present for several days before the eruption. This magnetic flux cancellation could be the cause of the eruption. This prominence eruption is also associated to the contraction and expansion of coronal loops located on the side of the erupting flux rope. The contraction occurs 19 min after the start of the prominence eruption indicating that this contraction is not associated with the eruption driver. Rather, this prominence eruption is compatible with an unstable flux rope where the contraction and expansion of the lateral loop is the consequence of a side vortex developing after the flux rope is launched.

Major solar energetic particles and their relationship to associated flares and CMEs

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We considered solar energetic particles from January 2022 to August 2023, covering the rising phase of Solar Cycle 25. Our study examines solar energetic particles and their associated events, including solar flares and coronal mass ejections. Solar energetic particles (SEPs) are high-energy particles ejected from the Sun during powerful solar events, such as solar flares and coronal mass ejections (CMEs). In total, there are thirteen solar energetic particle (SEP) events. Of these, eleven are associated with both solar flares and coronal mass ejections. Most flares producing SEPs are located in the northwest quadrant, accounting for nine events. Two events occur in the southwest quadrant, while two events are not associated with any flares. M- and X-class flares are responsible for producing strong SEP events. The speed of the CMEs is typically above 600 km/s. Of the thirteen events, eleven have speeds exceeding 1000 km/s, and two events have speeds above 600 km/s. All CMEs producing SEPs are halo coronal mass ejections. At the peak of solar activity, it is expected that solar energetic particle events will increase over time. Earth's magnetic field provides significant protection from SEPs, shielding the planet from many of their harmful effects. However, during particularly intense solar events, SEPs can penetrate the magnetosphere and reach lower altitudes, especially near the poles. In this paper, we illustrate solar energetic particles and their associated solar flares and coronal mass ejections as they approach Earth.

Estimation of Solar coronal magnetic field strength at meter wavelengths using augmented Gauribidanur RadioheliograPH (GRAPH)

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Estimation of solar coronal magnetic field strength (B) is of profound interest as it plays a major role in the dynamics of the solar corona like development of coronal structures, coronal activities, radio bursts, CMEs, background corona, etc. The B estimates in heliocentric distance range, $r \approx 1.2 - 3\ R_o$ is limited as the field strengths are in the order of few Gauss, where R_o is Photosphere radius. Also, the B estimates especially in the quiet coronal regions at these 'r' are rare. In the recent past, researchers have pointed out the possibility to estimate the B using thermal radio emission from the corona using magneto-ionic theory. They suggest that the B makes the plasma medium anisotropic and thereby splits the original randomly polarized thermal radio emission into two orthogonally circularly polarized components i.e., the ordinary and extraordinary modes. These two components are differently absorbed by the magnetized plasma due to the difference in absorption coefficients and the directions of the wave propagation. So, the resultant radiation will have the sense of circular polarization of the dominant component and detecting this degree of circular polarization (DCP) gives an idea about the B which caused it. Using Ray-tracing techniques, the variation of DCP for various radio frequencies, coronal electron densities and magnetic fields are investigated. The simulation results indicate that the DCP is low for higher radio frequencies and increases as we observe at lower radio frequencies (DCP is significant at meter wavelengths and above radiation).

In view of the above, to locate and detect the circularly polarized radio emission from solar corona, the GauribidanurRAdioheliograPH (GRAPH) array is being augmented. Present GRAPH is a T-shaped radio interferometric array that can produce 2D total intensity images in 35-85 MHz frequency range (corresponds to coronal observations at $r \approx 1.2\text{-}2.0$ Ro)

Comparative analysis of ICME characteristics and Geoeffectiveness across Solar Cycles 23, 24 and 25

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In this study, geoeffective CMEs from solar cycle 25 were collected and the relationship between ICME characteristics and geo-effectiveness was analyzed. The characteristics of ICMEs and Geoeffectiveness were examined and compared separately with those from the rising phases of previous solar cycles. A strong correlation was found between ICME geo-effectiveness and the southward component of its magnetic field. Similarly, for sheaths, a significant correlation was observed between their southward magnetic field and geo-effectiveness. The size of ICME regions was found to be larger than that of sheath regions. Overall, when solar cycle 25 was compared with the two most recent solar cycles, minimal variation was observed compared to solar cycle 24, while solar cycle 23 remained the strongest in terms of geo-effectiveness.

Estimating the coronal magnetic field strength via CME-driven shocks : A comprehensive evaluation of stand-off distance (SOD) method

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We proposed the Stand-Off Distance (SOD) Method to estimate the coronal magnetic field strength via CME-Driven Shocks. In this study, we have analyzed the propagation characteristics of two limb Coronal Mass Ejections (CMEs) with their shocks for the period of 2017. Out of several CME events, we have identified two events which are associated with the TYPE-II Solar Radio Bursts. These two CME events which show a clear shock structure in the LASCO Field Of View (FOV). In this study, these CMEs were observed in 17 frames up to 17 Solar Radii using SOHO/LASCO white light running difference images. Gopalswamy and Yashiro introduced the Stand-Off Distance (SOD) Method to estimate the magnetic field in the corona using CME-Driven Shocks. We have used this technique to determine the magnetic field strength and to study the propagation/shock formation condition of these CMEs at 17 different locations. Since the thickness of shock sheath (Stand-Off Distance) is not constant around CME, we estimate the shock parameters and their variation in large and small SOD regions of the shock. Our results indicate that the SOD Method can provide a reliable and consistent estimate of the Coronal Magnetic Field and has potential for use in future space weather forecasting models. Estimating the coronal magnetic field strength provides valuable insights into various space weather phenomena and enables accurate forecasting. Additionally, this method provides important insight into the internal structure and dynamics of CMEs which might be aid in the development of improved CME prediction models.

KEYWORDS: Sun . Coronal Magnetic Field . Plasma Density . Coronal Magnetic Field

Effect of Coronal Mass Ejections during Lunar Phases of Full moon day and New moon day

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The effect of the solar activity such as coronal mass ejection (CME) during Lunar phases (full moon day and new moon day) has been a subject of interest in space weather studies. This study investigates the potential influence of lunar phases on the effects of CME by correlating CME data along with the occurrence of full moon day and new moon day during many years. The CME data from the Solar and Heliospheric observatory (SOHO) and Lunar phases data from United States Naval Observatory (USNO) are used for the investigation. The results revealed the possible correlation between the initiation time of CME and the lunar cycle, which could provide a picture to understand how the parameters of solar activity influences during lunar phases. The detailed results will be presented.

Keywords: Coronal Mass Ejection (CME), Lunar Phases, Space weather.

Trustworthiness of Sunspot's Magnetic Parameters in Predicting Coronal Mass Ejection Velocity

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The Sun's transient activities have the potential to cause significant disruptions on Earth, with coronal mass ejections (CMEs) being among the most impactful phenomena. CMEs are often initiated through magnetic reconnection in active regions or sunspots, although filaments can also contribute to their occurrence. Impulsive CMEs predominantly originate from sunspots, and their velocity is a key indicator of their dynamics and geoeffectiveness. As direct observations of CMEs in the interplanetary medium are challenging, forecasting their behaviour is critical for mitigating their effects. Can the CME velocity be reliably predicted using the magnetic parameters of their associated sunspots? To address this, we analyzed 36 CMEs from Solar Cycle 24, categorizing them into two groups: Group I (fast CMEs with velocities >700 km/s) and Group II (slow CMEs with velocities ≤700 km/s). We utilized SHARP magnetic parameters from sunspots and ranked them based on their correlation with CME velocity. Our findings reveal that the velocity of fast CMEs is strongly correlated with their associated sunspot parameters, indicating a promising predictive capability. However, the velocity of slow CMEs exhibited a poor correlation with SHARP parameters, making their prediction significantly more challenging. The underlying reasons for this disparity remain unclear, and further investigation is planned to uncover the factors driving this unexpected behaviour. These results underscore the potential of sunspot magnetic properties in forecasting fast CMEs while highlighting the need for more comprehensive studies to understand and improve predictions for slower events.

Studying flare ribbon dynamics using MHD simulation

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We have studied the properties of magnetic reconnection through flare ribbons dynamics using observations and data-constrained magnetohydrodynamics (MHD) simulation. We have estimated the reconnection flux and the reconnection flux rates using flare ribbons observed in 1600 channel in Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO) of an M1.1 flare hosted by the active region 12184 on May 23, 2021. We find the reconnection flux and corresponding flux rates to be 10^{20} Mx and 10^{18} Mx/s respectively. To understand the origin of flare ribbons, we have performed an MHD simulation initiated by the non-force-free extrapolated field. Importantly, we have identified a three-dimensional (3D) magnetic neutral point and a flux rope in the flaring region, which are crucial to the flaring activity. The reconnection initiates at the null point and the flux rope also appears to reconnect at the null point, which is favorable for the eruption of the filament. We trace the footpoint evolution of the field lines lying over the flare ribbons and find a significant matching between the observed flare ribbons and the evolution of footpoints computed from the MHD simulation. In the simulation, we have calculated the reconnection flux and flux rates using the pixels under these footpoints and found one order higher in comparison to their observed values. Additional findings are the enhancement of vertical current density near the flaring ribbons, a signature of successive reconnections near the null point. Overall, the present work contributes to the understanding of the ribbon formation in a flaring process and estimates one of the fundamental quantities i.e. reconnection rate important to magnetic reconnection, found almost similar to the previous calculations.

Geo-effectiveness of non-active region interplanetary CMEs: initiation, propagation and near-Earth consequences

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In this work, we report on a multi-wavelength and multi- instrument study of a partial coronal mass ejection (CME) that occurred between October 31, 2023, and November 3, 2023, from non-active region (AR) solar locations S18W10, S15W32, and N29W32. These CMEs caused one of the largest geomagnetic storms with a minimum Dst = -163 nT. The Atmospheric Imaging Assembly measurements from the Solar Dynamics Observatory in the hot EUV channel of 94 Å verify that these CMEs are not related to a coronal sigmoid that prior to the eruption started to exhibit an intensive emission (T ∼ 6 MK) from its core. The fundamental triggering mechanism of these flux rope eruptions appears to be tether-cutting reconnection and magnetic loop breaking, as shown by multi-wavelength observations of the source active region. It is noteworthy that throughout the large-scale flare initiative process, a composite of three various C-class flares was generated from each solar position to produce a single flare. Following the flux rope eruption, a moderate three different partial halo CMEs are observed coronagraphically, with linear projected speeds of 634, 561, and 693 km s^{-1} respectively. These three disc center-originating CMEs are interacted and the CME–CME interaction scenario in the interplanetary medium is validated by the height–time charts of the CMEs that transpired between October 31 and November 3, 2023. Three distinct aspects of rapid storm commencements are observed in in-situ measurements of the solar wind magnetic field and plasma parameters at 1 AU. These features are separated by three discrete jumps in the plasma properties. The interaction between the three CMEs mentioned above in the near- Earth interplanetary medium has been instrumental in significantly increasing the geo- effectiveness of this group of three partial halo CMEs.

Observations of radio bursts association with halo CMEs and M-class solar flares

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We report on a study of the observations of single and multiple types of radio bursts associated with 157 halo CMEs and M-class solar flares occurred during the period 1997 – 2014. Among the 157 halo CMEs, which are detected by the *Solar and Heliospheric Observatory* (SOHO) / *Large Angle Spectrometric and COronograph* (LASCO), 96 (61%) of them are associated with deca-hectametric (DH) type II burst observed by Wind/WAVES. Out of 96 events, 62 (65%) are associated with more than one type of radio emissions, i.e., they appear along with any one or more among the metric/DH type II, type III and IV radio bursts. 16 events (~17%) have all three types of types of radio bursts (II/III/IV) and 48 events (50%) have type IIs in both metric and DH domains. It is found that there are some events associated only with metric type II (8%), type III (8%) or type IV (8%) radio bursts.

Key words: Solar flares, CMEs, radio bursts.

Study on quick and delayed major SEPs based on the onset of type II radio bursts

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On the raising concern about the solar energetic particles (SEPs) that affect our space weather conditions is immediate important. In this study we focus on the characteristics analysis of quick and delayed major SEPs based on the onset of DH type II radio bursts for the solar cycle 23 and 24. Out of 110 SEPs events, 49 events are identified as quick SEPs (≤ 60 min) and the remaining 61 events are considered as delayed SEPs (>60 min). All the characteristics of SEPs, their associated solar eruptions, and the relationships between them are statistically analyzed and compared. Interestingly, we found that relative elemental abundances of the seed populations (Fe/O ratios) of quick SEPs (0.48) are significantly lower than that of the delayed SEPs (2.3). Our results also point out that the quick SEPs (Rise time = 716 min) are impulsive, and the delayed SEPs (Rise time = 1384 min) seem to be gradual. On average, the peak intensity of the quick SEPs is twofold larger than the delayed SEPs events. It is also noted that there are no significant differences between the properties of SEPs associated with solar flares and CMEs for both sets of populations. The results indicate that the seed populations are the predominant factor for the earlier onset of SEP events.

Radio analysis of solar activities associated with 25 Feb 2014 day event

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We present a detailed study of an earth-directed fast and wide Coronal Mass Ejection (CME) event on 25 February 2014. The complex magnetic configuration in Active Region (AR) 11990 at S12E82 caused an intensive X4.9 flare with a peak at 00:49UT. Then a massive halo CME event was obtained in LASCO C3 coronagraph with a linear speed of 2150 km/s. The radio flux emission at multi-frequency channels was observed by Learmonth radio spectrograph. Metric Type II radio emissions were detected by Culgoora radio spectrograph. First metric Type II was detected in the frequency range 75 MHz – 18 MHz during 00:56 UT-01:02 UT. The continuation of this plasma emission was observed in low frequency range 14 MHz – 100 kHz by space borne Wind/WAVES instrument. The second metric Type II was observed in the frequency range 90 MHz – 28 MHz during the period 01:02 UT-01:17 UT. From the OMNI data, the shock of the CME reached earth's magnetosphere on 27 Feb 2014 at 17:00 UT. A fast forward type shock was observed using OMNI high resolution data. The interplanetary properties of the shock parameters are calculated using magnetic vectors and velocity vectors. The shock normal vector, unit normal vector and tangential vectors are estimated. The difference between shock normal angles and unit normal angles between magnetic and velocity vectors are nearly ~90°. It suggests that the shock propagation is normal to magnetic field direction. The IP shock and ICME affected the Cosmic ray detection. Large magnetic turblances in sheath region caused multilevel minimum storm index.

Keywords: Active Region – Solar flare – CME – IP shock – Space weather.

Investigations on coronal mass ejections associated with flares and DH type II radio bursts of solar cycle 25 from January 2020 to December 2023

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In this study, the parameters of coronal mass ejections (CMEs) associated with flares and DH type II radio bursts of solar cycle 25 from January 2020 to December 2023 have been investigated. It is found that most of the associated CMEs are found to be from M-class flares (63.3%), followed by 20% C-class flares and with only 16.6% from C-class flares. Other parameters like the annual distribution of flares according to their class, their location, the starting and ending frequencies of DH type bursts associated with CMEs have also been investigated. This data and trend along with the upcoming ones can be used to understand CMEs better and to compare with past solar cycles.

Key words: Sun, coronal mass ejection, solar cycle 25, solar flare, DH type II bursts.

Poster Presentation

Examining CME-Driven Type II Radio Bursts: Insights from Multi-Instrument Observations from Solar Cycle 24

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This work analyzes a set of 16 type II radio bursts from the Wind/WAVES experiment recorded during the 24th solar cycle (2008-2019) in conjunction with coronal mass ejections (CMEs) observed by the Large Angle and Spectrometric Coronagraph aboard the Solar and Heliospheric Observatory (SOHO/LASCO), as well as images of solar radio emissions from the Nancay Radio Heliograph (NRH). Type II radio bursts are generated at the shock ahead of CME through the acceleration of non-thermal electrons. The NRH observatory observes the Sun for about seven hours daily across several frequencies between 150 and 450 MHz. The aim of this study is to identify the association between radio bursts and CMEs and to investigate CME/shock kinematics.

Study of a Halo CME and its Associated Activities observed on March 23, 2024

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This study presents a comprehensive analysis of solar activity detected on March 23, 2024. Using multi-instrument data, we examine the propagation characteristics of a Coronal Mass Ejection (CME), properties of soft X-ray emissions from solar flares, DH Type II radio burst signatures, and interplanetary conditions at 1 AU. The CME is identified as a fast, Earth-directed halo CME, accompanied by an intense X-class solar flare. Additionally, interplanetary parameters, including Alfvénic conditions, shock wave features, and ICME properties, are analyzed. The findings contribute to understanding the solar-terrestrial interactions of this significant event, and results will be presented.

Transit time of CME/shock associated with a major geo-effective CME in solar cycle 25

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The concept of space-weather greatly depends on the kinematics of coronal mass ejections (CMEs) in the interplanetary medium. This paper's primary goal is to investigate the propagation of a significant geo-effective CME and the shock that accompanied it that was seen in solar cycle 25. The ACE/wind in situ data that is accessible in the OMNI data set shows the arrival of the interplanetary shock and CME of these events close to Earth. In the LASCOfield ofview, theCME taken into consideration in this work has a quickerone, close to 1280 km/s.The transit time estimated by the empirical shock arrival model (ESA) is compared with the observed transit time of the event. In particular, we use (i) several acceleration-speed equations from observations from the last few decades published in the literature, and (ii) different acceleration cessation distances (Acd). Furthermore, wecontrasted the transit time obtained from the Drag Based Model (DBM) with the estimated and observed transit time. Based on the analysis's findings, we know that every CME acts differently in the interplanetary medium and that the CME's starting speed, the interplanetary acceleration, and the acceleration cessation distances control how quickly they propagate. Lastly, we provide the results of a multi-point analysis of a significant geo-effective CMEthat began at S20W26 and transpired on May 9, 2024, from active region 13664. This CME generated one of the strongest geomagnetic storm at a minimum Dst = - 412nT.

Solar wind and climate change on the Earth

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The solar wind is the constant flow of charged particles, mostly protons and electrons, that penetrates the solar system after escaping the Sun's corona, or outer atmosphere. These particles, propelled by elevated temperatures and pressures, move between 300 and 800 kilometers per second while interacting with the atmospheres and magnetic fields of planets. When solar wind particles arrive on Earth, they come into contact with the magnetosphere, which has a variety of impacts. When charged particles collide with atmospheric gases close to the poles, they form the aurora, also known as the Northern and Southern Lights, one of the most visible effects of solar wind interactions. The solar wind gets stronger and has the ability to cause geomagnetic storms at times of high solar activity, such as solar flares and coronal mass ejections (CMEs). Space weather monitoring is essential because of the severe effects of these storms, which can interfere with satellite communications, GPS systems, and even terrestrial power grids. To lessen these effects, scientists are trying to predict and better understand solar wind patterns. The significance of space weather research for safeguarding contemporary technology systems explores the origin, behavior, and environmental impacts of the solar wind.

Keywords: Solar wind, space weather, geomagnetic storms, auroras, magnetosphere

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Discerning the contribution of small and large-scale magnetic fields on the X-ray flux of the Sun

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The Sun's surface hosts magnetic fields in two forms: large-scale fields concentrated in active regions and small-scale fields dispersed across the entire surface. The magnetic field influences the Sun's radiative output and is the primary source of all solar surface features. Researchers have studied the relationship between magnetic flux and X-ray luminosity for decades, proposing various power-law relations. However, the relationship between large-scale and small-scale magnetic fields and X-ray flux remains an open question. This work aims to study the correlation between large-scale, small-scale, and X-ray flux of the Sun. For this study, we used synoptic charts of the photospheric line-of-sight (LOS) magnetic field from Carrington Rotations (CR) 2097 to CR 2286 from the HMI instrument for magnetic field data, and X-ray flux data from the GOES satellite, TIMED, and SORCE spacecraft. We reconstructed the large-scale magnetic field (low l degree) and the small-scale magnetic field (high l degree) using spherical harmonics. After calculating B_{avg} over time, we studied the correlation between large-scale, small-scale, and X-ray flux from different satellites for l_{max}=5 and l_{max}=10. We find that small-scale magnetic fields show a better correlation with X-ray flux than large-scale magnetic fields, with significant implications for space weather.

Temperature profile of Martian lower atmosphere and study its variation with seasons, through the day and with solar activity

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Mars is the planet that is most similar to our Earth. But it has a thinner atmosphere and extreme seasons. The Martian atmosphere is about 100 times thinner than the Earth's atmosphere. It has an average temperature around 210°K and average pressure is about 6.1hPa (Haider.S.A,2023). However, the temperature of Mars is highly variable diurnally, seasonally and with the location on the planet. The objective of this paper is to analyse the temperature of Martian lower atmosphere and study its variation with seasons, through the day and with solar activity. To employ this the radio occultation data from two important Mars missions is used; Mars Reconnaissance Orbiter and Mars Global Surveyor. During visualisation of datasets, it was found that there was lack of observation in certain latitude and longitudes. To rectify it, three interpolation methods; Radial Basis Function, Inverse Distance Weighting and Nearest Neighbour were looked into. From the analysis, it was concluded that NN interpolation was the best fit for temperature profiling. The IDW method also provided good results. However, RBF interpolation was found to be unsuitable.

On the Effective Rotational Temperature of Large Sunspot Umbra using $E^2\Pi - X^2\Sigma^+$ System of CaH Molecule

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In the present work, a significant rotational line of $E^2\Pi - X^2\Sigma^+$ (0,0) band system of CaH molecule was identified in high resolution FTS sunspot umbral spectra in the region from 20,207 to 20,656cm^{-1}. Using the well resolved identified lines, the rotational temperatures have been estimated to be 2952 K for photosphere and 2244 K for hot umbra. Further, the oscillator strength, column density, optical depth, Einstein coefficients and radiative lifetime for well resolved identified lines of $E^2\Pi - X^2\Sigma^+$ (0,0) band system of CaH molecule have been estimated. Hence, the estimated parameters and the effective rotational temperatures of CaH molecule gives the evidence that the presence of CaH molecule in higher temperature regions like sunspot umbra, star forming regions and interstellar atmosphere.

References

1. Ram, R.S., Tereszchuk, K., Gordon, I.E., Walker, K.A., Bernath, B.F.: 2011, *J. Mol. Spectrosc.***266**, 86.
2. Sindhan, R., Sriramachandran, P., Shanmugavel, R., Ramaswamy, S., 2023. On the effective temperature of large sunspot umbra using AlH molecular lines.*New Astron*. **99**, 101939.
3. Wallace, L., Livingston,W.C., Bernath, P.F., Ram, R.S.: 1998, An atlas of the sunspot umbral spectrum in the red and infrared from 8900 to 15 050 cm^{-1} (6642 to 11230 Å). Tech. Rep. 98–001(Tucson:NSO).
4. Wallace, L., Hinkle, K., Livingston, W. C.: 2000, An atlas of sunspot umbral spectra in the visible from 15,000 to 25,000 cm-1 (3920 to 6664 Å).Tec.Rep. 00-001(Tucson:NSO).

Investigation on Coronal Mass Ejections and Groups of Type III Radio Bursts during Solar cycle 23

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We present a statistical study of the temporal association between the groups of Type-III radio bursts (small groups & large groups) and the coronal mass ejections (CMEs). The analysis considers CMEs that erupt within 30 minutes after or before the generation of Type-III radio bursts. The data covers the period 1997–2008, the sunspot maximum to the sunspot minimum period of the 23rd solar cycle. Our results show that the majority of Type III groups and those that follow would be CMEs, and the percentage association is found to vary inversely with respect to the sunspot cycle. The influence of the solar flares (Hα flares and X-rays) on the above results was checked by removing their contribution, and the results were found to be unaffected, indicating the role of flares is minimal with regards to the occurrence of groups of Type-III radio bursts. Finally, we tried to distinguish between the CMEs that erupt before the Type-III groups and the ones that follow based on the magnitude of the associated CME acceleration. We found that both categories show a similar trend, indicating that the association is independent of the acceleration. Nevertheless, we found that the majority of the CMEs (onset before as well as after the onset of Type-III groups) have acceleration values in the range -10 ms^{-2} to +10 ms^{-2}.

Investigations of changes in sunspot properties leading to coronal mass ejections

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Coronal Mass Ejections (CMEs) are the highly magnetized plasma that drive shocks and accelerate particles from the sun. The present study investigates the characteristics and behaviour of long-lived sunspots during the 24th solar cycle through the analysis of CMEs. A dataset comprising long-lived sunspots was collected, focusing on the day before and after CME ejection events. Changes in the Hale and McIntosh sunspot classifications were analyzed alongside the average count and area of sunspots, revealing patterns in their evolution. Graphical representations were constructed to illustrate the relationship between sunspot properties and CME behaviour, including plots of sunspot area versus CME velocity and changes in area pre- and post-ejection. The findings provide insights into the dynamics of long-lived sunspots and their association with CME activity and contribute to our understanding of solar phenomena.

Mars Perseverance Images to Validate Solar Far-Side Active Regions

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The Perseverance Rover has been on the Martian surface since February 2021. The rover has Mastcam-Z navigation stereo cameras (Kinch et al., 2020) that can capture direct images of the Sun's surface. During periods of Mars's orbit, the rover has a unique view-point of the Sun's far-side (not visible from Earth at any given time). Solar scientists can use the rover's conveniently positioned cameras to monitor sunspots that we cannot otherwise observe. By collecting these data, we can verify helioseismic detections of the Sun's largest far-side active regions. In this project, solar far-side acoustic images obtained using time-distance helioseismology (Zhao et al., 2019) and SDO/HMI Dopplergrams (Scherrer et al., 2011) are compared with white-light observations from the Perseverance Mastcam-Z cameras. By taking advantage of Mars' orbital positioning, our goal is to refine the acoustic "true/false positive" detections in the helioseismic maps. Ultimately, this can help improve the assimilated boundary conditions of coronal and solar wind models, which in turn can aid in more accurate space weather forecasting.

Determining filament counts using H-alpha images of the Sun

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Filaments are essentially prominences seen as absorbing features on the disk of the Sun. Thus, from observations of Filaments taken at Kodaikanal Solar Observatory-Indian Institute of Astrophysics using H–Alpha Telescope the distribution of Filaments over the whole disk image can be studied. For the Solar Cycles 18, 19, 20 and 21 the Number of Filaments appeared on the Sun is Counted by using Sunspot, Faculae and Prominence Charts available at IIA's Data Archive, I have used 16789 days of data into the analysis. This covers about 50years. The obtained data are plotted and studied the cyclic behavior of the Filaments appearance on the Sun.

Investigations on coronal mass ejections of solar cycle 25 from January 2020 to December 2023

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Solar cycle 25 is predicted to be weak like the previous cycle 24, yet, there has been intense activity in the sun characterized by strong flares and geomagnetic storms. In this study, the parameters of coronal mass ejections (CMEs) like the number of CMEs occurring each year, their linear speed and angular width of the 25th solar cycle during the period of January 2020 to December 2023 have been investigated. It is found that most of the CMEs are found to be slow (63.8%), followed by 31.6% moderate and with only 4.5% of them are fast moving CMEs. Similarly, there is a higher percentage of intermediate CMEs when compared to narrow and wide CMEs. This data and trend alongwith the upcoming ones can be used to understand CMEs better and to compare with past solar cycles.

Key words: Sun, coronal mass ejection, solar cycle 25, linear speed, angular width

Survey of H, He, and C radio recombination lines in the inner Galactic plane and the Cygnus-X region

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A large-scale Radio Recombination Line (RRL) survey was conducted toward the inner Galactic plane (from -5° to 32° in longitude, |b| < 1°) and the Cygnus X region (l = 80° ± 2.75°, b = 1.4° ± 2.75°) using the Robert C. Byrd Green Bank Telescope. Known as GDIGS-low, this survey was done at 342 and 800 MHz, observing hydrogen, helium, and carbon RRLs with angular resolutions of 45’ and 15’, respectively.

Our observations reveal that the low-frequency HRRL emission in the Galactic plane and Cygnus-X region extends over several degrees, indicating it originates from Diffuse Ionized Gas (DIG). We explore the connection between the HRRL emission and the [NII] far-infrared fine structure lines observed by the Herschel Space Observatory (Goldsmith et al., 2015; Pineda et al., 2019), both of which originate in fully ionized gas. While we detected HRRLs in nearly all directions with [NII] lines, our analysis shows that the emission measure (EM) from [NII] accounts for only 5% or less of that from RRL data.

We used our survey data toward the Cygnus-X region to investigate helium ionization in the DIG. Previously, HeRRLs had not been detected in the DIG, which is puzzling since massive stars should ionize both hydrogen and helium. By masking emissions from HII regions in Cygnus-X, we spatially averaged the spectra and achieved the sensitivity needed to detect a HeRRL from the DIG at 800 MHz for the first time. We found that the ratio of ionized helium to hydrogen is 0.7, with an interquartile range of 0.05 to 0.11, similar to ratios reported in HII regions around O6 stars or earlier types.

We present how these results impact our understanding of the DIG's ionization and its connection to other components like the gas emitting [NII] lines.

Relationship between CME activity, geomagnetic storms, and precipitation pattern during rainy seasons

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This study explores the correlation between Coronal Mass Ejection (CMEs) and rainy season. Utilizing satellite data from NASA's, SOHO and SDO missions, weanalysed CME events and their subsequent impacts on earth's magnetic field, ionosphere and atmospheric pattern. The results indicate significant relationship between CME intensity, geomagnetic storms, and precipitation pattern during rainy seasons. Specifically, CME induced geomagnetic storms enhanced atmospheric ionization, influencing cloud formation and precipitation. Precursor signals from CME events improve rainy season prediction accuracy. It is proposed to develop a predictive model integrating CME parameters, geomagnetic indices, and atmospheric variables to forecast rainy seasons. This research contributes to the emerging field of space weather, offering a new tool for predicting rainy seasons.

Keywords: Coronal Mass Ejections, Rainy season prediction, space weather, geomagnetic storms.

Forecasting seasonal climate trends during coronal mass ejections activity

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To explore the relationship between coronal mass ejection and summer seasonal pattern utilizing statistical analysis and data visualization techniques. Using satellite data from SOHO/LASCO and the National Oceanic and Atmospheric Administration's (NOAA) space weather prediction centre. The powerful eruption of solar plasma is known to affect space weather and have been suggested to influence Earth's atmospheric condition. Using advanced statistical techniques and data analysis, this research predicts the correlation between CME activity and seasonal climates trends. The results indicate that certain CME patterns may have a discernible impact on summer season behaviour, opening up the possibility of using space weather data for more accurate seasonal forecasts. The study provides a foundation for exploring space-climates interactions and establish the potential for integrating solar activity data into long-term weather prediction.

Keywords: Solar corona,Coronal Mass Ejections, space weather.

On the Effective Rotational Temperature of Large Sunspot Umbra using C_2 Molecule

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The astrophysically significance of C_2 molecule is used to determine the physical and chemical nature of a solar or stellar region. With the aim to identify them clearly, we therefore analyzed the rotational lines of 3 (3,1) band system of C_2 molecule in high-resolution sunspot umbra spectra provided by the National Solar Observatory, Kitt Peak, in the wavenumber region from 13,650 to 13,855 cm^{-1} . Using the well resolved identified lines, the rotational temperature has been estimated to be 1369 K for cold umbra. Hence, the estimated the effective rotational temperature of C_2 molecule gives the evidence that the presence of C_2 molecule in sunspot umbra.

Computation of Radiative Transition Parameters of Dicarbon (C_2) molecule in the high temperature atmosphere, S-stars and sunspots

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The dicarbon (C_2) is a significant molecule in astrophysics. The radiative transition parameters such as Franck-Condon (FC) factor, r-centroids, electronic transition moment, Einstein coefficient, band oscillator strength, radiative life time and effective vibrational temperature have been computed for $d^3\Pi_g - c^3\Sigma_u^+$ system of C_2 molecule by the more reliable numerical integration procedure for the experimentally known vibrational levels using Rydberg-Klein-Rees (RKR) potential energy curves. For this system, the r-centroids increases with an increase the wavelength, hence this system is expected to be red degraded. The electronic transition moment with variation of internuclear distance has been evaluated and this is represented by $R_e(\bar{r}_{v'v''}) = const.\,(1 - 0.962\,\bar{r}_{v'v''})$ in the range of 1.046 Å < $\bar{r}_{v'v''}$ < 1.536 Å. The radiative lifetime for the $d^3\Pi_g$ (v'=0) state of C_2 molecule was found to be 77.89 ns. The effective vibrational temperature was found to be nearly 5682 K. Hence, the radiative transition parameters as well as effective vibrational temperature help us to ascertain the possible presence of C_2 molecule in the high temperature atmosphere, S-stars and sunspots. Keywords: C_2, Einstein coefficient, lifetime, vibrational temperature

Unraveling Solar Explosions: Insights into CME and ICME Dynamics through Multi-Wavelength Observations.

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The solar atmosphere, governed by the Sun's magnetic fields, is the origin of various solar activities, including solar flares and coronal mass ejections (CMEs), which are among the most energetic events observed in space. This study reviews multi-wavelength observations of CMEs and their interplanetary counterparts, ICMEs. ICMEs, characterized by solar-wind plasma and magnetic disturbances, often include magnetic clouds that propagate through the interplanetary medium, impacting space weather. We examine the multi-scale dynamics of magnetic energy conversion into kinetic energy and heat across different regions of the solar atmosphere. By analysing the observational data, we aim to improve our understanding of the instability processes and evolution of these explosive solar phenomena. This work advances our knowledge of the mechanisms driving solar explosions and their impacts on the heliosphere, with implications for predictive models of space weather.