39th Astronomical Society of India

Workshop – 6

Multi-payload and Multi-Observatory Science with Aditya-L1

Programme Schedule

09:30 – 09:35AM	Welcome
Session 1: Active Sun Physics	**Chair:** Bhuwan Joshi (PRL)
09:45 – 10:00AM	Solar Flare Studies using Aditya-L1 – Sreejith, P (IUCAA)
10:05 – 10:20AM	Prospects of microflare studies with Aditya-L1 - Mithun, NPS (PRL)
10:25 – 10:40AM	Studies of Waves in Active Regions using Aditya-L1 and other observatories - Aishawnnya Sharma (Tezpur Univ)
10:45 – 10:55AM	DISCUSSIONS
Session 2: Coronal Magnetic Field Diagnostics	**Chair:** Dibyendu Nandi (IISER-Kol)
10:55 – 11:10AM	Exploring coronal magnetic structures related to solar eruptive events: Aditya-L1 perspective - Ramit Bhattacharyya (USO/PRL)
11:15 – 11:30AM	Multi-height Magnetic Field Measurements and Forward Modeling – Rohan Eugene Louis (USO/PRL)
11:35 – 11:50AM	Data Driven Models for Coronal Magnetic Field: Aditya-L1 Perspective – Soumyaranjan Dash (IISER-Kolkatta)
11:50 – 12:00PM	DISCUSSIONS
Session 3: CME Initiation and Propagation	**Chair:** Rajaguru SP (IIA)
12:00 – 12:15PM	CME propagation in Inner Corona: science with Aditya-L1 – Vaibhav Pant (ARIES)
12:20 – 12:35PM	CME studies with Aditya-L1 and multi-wavelength Observations – Sasikumar Raja (IIA)
12:40 – 12:55PM	Contribution of Aditya-L1 observations in forecasting the magnetic profiles of Earth-directed CMEs – Sanchita Pal (IISER-Kolkatta)
13:00 – 13:15PM	DISCUSSIONS
13:15 – 14:15PM	**LUNCH**
Session 4: Quiet Sun Physics	**Chair:** Durgesh Tripathi (IUCAA)
14:15 – 14:30PM	Quiet Sun Transient Studies with Aditya-L1 and other observatories – Tanmoy Samanta (MSFC)
14:35 - 14:50PM	Deriving coronal plasma parameters with Aditya-L1 and multi-wavelength observations – Krishna Prasad (KULeuven)
14:55 - 15:10PM	Multi-height observations of waves in the solar atmosphere – Avyarthana Ghosh (IUCAA)
15:15 – 15:25PM	DISCUSSIONS
Session 5: Solar Wind and Heliospheric Studies	**Chair:** Dibyendu Chakrabarty (PRL)
15:25 – 15:40PM	A Forecasting framework for Solar Wind and its implications on in-situ measurements from Aditya L1 – Bhargav Vaidya (IIT Indore)
15:45 – 16:00PM	Solar Wind Studies with Aditya-L1 and Multi-wavelength – Susanta Bisoi (NIT Rourkela)
16:05 – 16:20PM	Geoeffectiveness of CME and CIR driven storms on the radiation belt electron flux variations – B. Veenadhari (IIG Mumbai)
16:20 – 16:30PM	DISCUSSIONS
Mega Science Vision (MSV) Discussion	**Chair:** Dipankar Banerjee (ARIES)
16:30 – 17:00PM	MSV for Solar Physics – Dibyendu Nandi (IISER-Kolkatta)

Session 1: Active Sun Physics

Solar flare studies using Aditya L1

P. Sreejith

Abstract: Solar flares are sudden eruptions of energy from the sun. This energy is distributed across the spectrum ranging from gamma rays to radio waves. Different payloads on Aditya-L1 will be observing the sun in X-rays and ultraviolet to study solar flare events. Uniquness of having a UV imging telescope as well as hard and soft X-ray paylaods with high sensitivity and high spectral resolution on the same observatory will be very useful for solar flare studies. This presentation will be covering the prominent science problems regarding solar flares, that can be addressed with multi-wavelength payloads onboard Aditya -L1 space observatory.

Prospects of microflare studies with Aditya-L1

Mithun N. P. S.

Abstract: Small scale reconnection events, often termed as nanoflares, theorized to have energies about nine orders of magnitude lower than the typical large flares, are considered to be one of the mechanisms by which the solar atmosphere is heated. As direct observations of individual nanoflare events remain elusive with the current generation instruments, there has been considerable interest in studying the intermediate strength microflares. Observations of microflares can provide insights into the characteristics of the weaker events and their contribution to coronal heating. In this talk, I will discuss some of the recent investigations of microflares, particularly in the X-ray wavelengths, and bring out areas where observations with Aditya-L1 can contribute.

Sunspot waves and oscillations through SUIT.

Aishawnnya Sharma

Abstract: One of the wave modes observed in active region is sunspot waves. Sunspot atmosphere manifests different waves and oscillations in different layers of the solar atmosphere such as umbral flash oscillation, umbral and penumbral waves, coronal waves etc. Recent studies have reported occurence of beat like phenomenon in the sunspot atmosphere. Sunspot waves have also been observed to affect triggering of small scale explosive events like active region jets in the solar atmosphere. But the understanding of the origin of these different wave phenomena in the lower solar atmosphere is not yet complete. In this regard, various narrow-band channels of Solar Ultraviolet Imaging Telescope (SUIT) onboard Aditya- L1 will be able to provide fine details to connect our coronal understanding to the lower solar atmosphere. In this talk, the speaker will talk on the possible science that can be extracted by using observations by SUIT on sunspot waves.

Session 2: Coronal Magnetic Field Diagnostics

Exploring coronal magnetic structures related to solar eruptive events: Aditya-L1 perspective

Ramit Bhattacharyya

Abstract: Solar eruptive events and generally, the coronal transients, are manifestations of magnetic reconnection in which the magnetic free energy gets converted into heat and plasma flow along with rearrangement of magnetic field lines. Exploration of magnetic structures related to these events is a challenge in solar and space physics that requires a combined approach of multi-instrument observations and data based numerical simulations. Contextually, the Aditya-L1 mission, standalone or in combination with other space/ground based observatories, can effectively enrich the present understanding and pave a way for new ideas. In this presentation, the focus will be on the extrapolation of coronal magnetic field, its usage in magnetohydrodynamic simulations and their overall synergy with relevant payloads on Aditya-L1.

Spectro-polarimetric Diagnostic Tools for Investigating Solar Magnetic Flux Emergence

Rohan Eugene Louis

Abstract: Solar magnetic fields emerge on a wide range of spatial and temporal scales. It is of paramount importance to study flux emergence as it couples the different atmospheric layers and is the driver of energetic/eruptive events such as flares and mass ejections. Inferring the properties of the magnetic field throughout the solar atmosphere requires different spectro-polarimetric diagnostic tools that incorporate the physics of the interaction of radiation in a magnetised plasma. This talk will describe various spectral inversion codes and forward modeling techniques routinely employed in investigations of flux emergence, to extract physical parameters in the solar photosphere, chromosphere, and corona.

Data Driven Models for Coronal Magnetic field: Aditya-L1 perspective

Soumyaranjan Dash

Abstract: Solar coronal magnetic field dynamics drive the spaceweather. Due to the bright photosphere and low coronal density it is difficult to measure the coronal magnetic field accurately. Data driven modelling of the coronal magnetic field is one of the ways to understand the onset of solar storms and predict them. For constraining these models it is essential to have observations of the solar corona which is only possible during total solar eclipses and space based coronagraphs. Aditya-L1 is the Indian mission to observe different layers of the Sun (e.g. chromosphere and corona) from Lagrange-1 point. One of the payloads, called Visible Emission Line Coronagraph (VELC) is dedicated to observe the solar corona upto 3.0Rsun which will help constrain the numerical models. Employing the century-scale calibrated Surface Flux Transport (SFT) model and Potential Field Source Surface (PFSS) model we predicted the coronal magnetic field structure and polarization characteristics for several past total solar eclipses. Here we discuss the possible insights from such simulations in connection to different payloads of Aditya-L1.

Session 3: CME Initiation and Propagation

CME propagation in Inner Corona: science with Aditya-L1

Vaibhav Pant

Abstract: Coronal mass ejections (CMEs) are the main driver of the space weather. Thus, it is crucial to understand their kinematics in the heliosphere. For the past two decades, our understanding of CMEs has been vastly improved due to the launch of Solar and Heliospheric Observatory (SoHo) and Solar Terrestrial RElation Observatory (STEREO) spacecrafts. Despite decades of research, our knowledge of the propagation of CMEs in the inner corona (< 3R) is limited due to non-availability of the instruments that can take images of the inner corona with good signal-to-noise ratio (SNR). The Visible Emission Line Coronagraph (VELC) on board ADITYA-L1 will provide an uninterrupted view of the inner solar corona in the white-light continuum and emission lines centred at visible and infrared wavelengths with reasonable SNR. High-spatial, temporal and spectral resolutions of VELC combined with other instruments onboard ADITYA-L1 will allow us to shed lights on some of the less understood phenomena during the propagation of CMEs in the inner corona. In this talk, I will elucidate some of the studies on the kinematics of CMEs in the inner corona that can be performed with ADITYA-L1.

CME studies with Aditya-L1 and multi-wavelength Observations

K. Sasikumar Raja

Abstract: Aditya - L1 is the first Indian space mission to study the solar corona and solar wind. The mission is designed to monitor the solar corona and solar wind at multiple wavebands in the electromagnetic spectrum (i.e., visible, ultra-violet, soft x-ray, and hard X-ray wavelengths). Apart from these remote sensing observations, the mission is planned for in-situ measurements. It is worth mentioning that radio and microwave observations can be carried out using ground-based facilities. In this talk, I will present observations of coronal mass ejections (CMEs) using the payloads onboard Aditya-L1 and ground-based radio and microwave observations. For instance, one of Aditya-L1 payload - visible emission line coronagraph (VELC) and ground-based radio and microwave observations probe the same height in the solar corona (i.e., 1.05 - 3 solar radii). So far, such observations are rare and give unique opportunities to study coronal features like CME-driven shocks, blastwave driven shocks, the core of the CMEs, and many more. Further, I will discuss the synergy of observations and the challenges involved in carrying out the multi-wavelength observations using payloads onboard Aditya-L1 and ground-based facilities.

Contribution of Aditya-L1 observations in forecasting the magnetic profiles of Earth-directed CMEs

Sanchita Pal

Abstract: The Earth's magnetosphere gets magnetically connected and exposed to the heliospheric environment when it reconnects with the solar transient events like coronal mass ejections (CMEs). Reconnection is favored when a CME arrives at Earth with a prolonged southward magnetic field component. Thus, the prediction of an Earth-directed CME's magnetic profile is essential in estimating its geomagnetic response. We present an approach for forecasting the magnetic vectors within the Earth-directed segments of CMEs that utilises near-Sun CME observations to constrain its propagation in the Sun-Earth medium. The configuration of a flux-rope CME is approximated as a radially expanding force-free cylindrical structure. Combining near-Sun geometrical, magnetic, and kinetic properties of CMEs with the drag based ensemble and cylindrical force-free model, we predict the Earth-arrival time, speed, radial extension, and magnetic vectors of associated CMEs during their passage through 1 AU. The de-projected CME geometrical parameters and kinematics can be obtained using Visible Emission Line Coronagraph (VELC) observations onboard Aditya-L1 and the Sun-Earth Connection Coronal and Heliospheric Investigation (SECCHI) coronagraphs onboard STEREO. The magnetogram and Ultraviolet observations of CME solar sources using Helioseismic and Magnetic Imager (HMI) onboard SDO and Solar Ultraviolet Imaging Telescope (SUIT) onboard Aditya-L1, respectively, can be used to constrain CME magnetic properties while propagating from the Sun to Earth. Also, the prediction of CME magnetic vectors resulting from our model can be assessed using Magnetometer instrument's observations onboard Aditya- L1. Thus, remote sensing and in situ observations of Aditya-L1 can be utilised in constraining CMEs' geometry and magnetic nature and improve the forecasting of CME geoeffectiveness.

Session 4: Quiet Sun Physics

Quiet-Sun transient studies with Aditya-L1 and other observatories

Tanmoy Samanta

Abstract: In this talk, I will focus on studying small-scale transients and waves in the quiet-Sun regions of the solar atmosphere. I will discuss how the advent of new instruments with increasing spatial, temporal, and spectral resolutions improving our understanding of small-scale dynamics. Mainly, I will talk about the origin of small-scale transients (e.g., spicules, network jets, etc.) in quite-sun regions and their role in the upper solar atmosphere. I will also talk about MHD waves that are often observed in the chromosphere and corona. I will briefly review the importance of studying these transients/waves and further discuss how the various instruments onboard ADITYA-L1 along with co-ordinated observation from other telescopes, will improve our understanding of these phenomena.

Deriving coronal plasma parameters with Aditya-L1 and multi-wavelength observations

Krishna Prasad

Abstract: Modern observations revealed ubiquitous presence of magnetohydrodynamic (MHD) waves in the solar atmosphere. Both longitudinal and transverse oscillations have been found. Although spectroscopic observations are necessary to properly distinguish different wave modes and characterise their oscillation properties, the longitudinal oscillations are often observed with imaging observations alone, in particular, in the EUV wavelength bands. Spectroscopic observations also facilitate deriving additional properties, for instance, the excess broadening of spectral lines (on top of the expected thermal broadening) which is often associated with MHD waves and/or turbulence. Besides pursuing the main objective of identifying the role of MHD waves in the coronal heating, these oscillations are often utilised to extract important coronal parameters such as the plasma temperature, magnetic field strength, transport coefficients, sub-resolution structure etc. In this talk, I will discuss how the high-cadence and multi-wavelength capabilities of Aditya-L1 can be exploited to derive some of these parameters. Possible coordination with DKIST will also be discussed.

Multi-height observations of waves in the solar atmosphere

Avyarthana Ghosh

Abstract: The Solar Ultraviolet Imaging Telescope (SUIT) on-board the Aditya-L1 mission is a unique instrument providing high cadence images in the wavelength range 200-400 nm, with a plate scale of 0.7”/pixel from the Lagrangian-1 point of the Sun-Earth system. It has a suite of 11 science filters, out of which 8 narrowband filters, centered at different wavelength range, focus on imaging the two solar atmospheric layers, namely, the photosphere and chromosphere. The photosphere manifests a multitude of oscillatory motions, which propagate to the upper layers depending on the cut-off frequencies. As these oscillations/waves move upward, they steepen to form shocks and in the process, dissipate their energy. A significant amount of the energy dumped by the waves is supposed to contribute to the energy budget of the intermediate layers of the solar atmosphere, a fraction of which eventually propagate farther up in the transition region and corona. With the high cadence, high-resolution observations of SUIT, we aim at understanding the transfer of energy and plasma amongst these layers through waves. Such observations from SUIT will provide us with a comprehensive understanding of the energy transfer and dynamic coupling of the solar atmospheric layers.

Session 5: Solar Wind and Heliospheric Studies

A Forecasting framework for Solar Wind and its implications on in-situ measurements from Aditya L1

Bhargav Vaidya

Abstract: Coronal mass ejections and high speed solar streams serve as perturbations to the background solar wind that have major implications in space weather dynamics. Therefore, a robust tool for accurate predictions of the background wind properties is a fundamental step toward the development of any forecasting framework. In this talk, I will review the work carried out at IIT Indore towards developing a data-driven framework for forecasting solar wind parameters. In particular, I will describe the pilot study comparing several models based on empirical formulations and numerical simulations adopted for estimating in-situ measurements of solar wind properties like density, proton temperature, velocity and magnetic field polarities at L1. Additionally, in this talk, I will highlight the need for adopting hybrid MHD simulations aiming to study acceleration of solar wind particles. I will also discuss the relevance of such a framework in complimenting the in-situ measurements from the Aditya L1 payloads such as ASPEX and PAPA.

Studies of solar wind using ground-based interplanetary scintillation and ADITYA-L1 observations

Susanta Kumar Bisoi, P. Janardhan, and D. Oberoi

Abstract: Solar photospheric fields modulate the solar wind, whose interaction with the Earth's space environment is commonly known as "Space weather", which is one of forefront research areas in recent times. Studies of solar photospheric magnetic fields have reported a continuous decline in their strength for more than the past two decades that has been seen to be continued till date. As expected, the signatures of the long term changes in solar photospheric fields has been reflected in the solar wind as well as in the interplanetary magnetic field (IMF) near 1 AU. The near Earth observations of solar wind parameters and the IMF have been though continuously obtained in the past few decades through in-situ spacecraft observations, however, the scanning of the inner heliospheric solar wind between the solar corona and 1 AU has only been possible with the recent launch of Parker's solar probe in 12 August 2018. Prior to that it is only possible to study the inner heliospheric solar wind through the regular ground based remote sensing interplanetary scintillation (IPS) observations. Using the IPS observations of the past few decades, our studies through the measurements of solar wind turbulence levels have validated the fact that the declining solar activity is actually global in nature, with the solar wind density fluctuations varying in sync with the photospheric fields. However, the actual picture is still eluding us. The launch of ADITYA L1, India's first solar space mission, will be a real boon for us to study the properties and behaviour of solar wind in the inner heliosphere in tandem with the IPS observations, which in particular, I will discuss in my talk.

Geoeffectiveness of CME and CIR driven storms on the radiation belt electron flux variations

B. Veenadhari, M. Pandya

Abstract: The eruptions from the Sun in the form of Coronal Mass Ejections (CMEs) and Co-rotating Interaction Regions (CIRs) can drastically affect the charged particles population trapped in the Earth's Van Allen radiation belt. The solar sources of CME and CIR storms, their interplanetary conditions had an impact on electron flux and found distinct difference in their variations. The variation in the solar wind properties can vary the electron flux responses in different L-values and energies. Using Van Allen Probes observations, it is observed that at L = 3 and E = 3.4 MeV, for >70% cases the electron flux remains stable, while at L = 5, for ~82% cases it changes with the geomagnetic conditions. Moreover, a distinct change in electron flux response is observed for two different category of storm drivers (namely CME and CIR). Besides statistical analysis of CME and CIR driven storms, the role of solar wind driving conditions based on magnitude of IMF Bz, Vsw, and Psw is also studied and the acceleration mechanisms are discussed. The results will be a kind input for the designing of q multi-payloads of Aditya –L1 mission.