IAU-390 Symposium

A Multi-Point view of the Sun: Advances in Solar Observations and in Space Weather Understanding

ABSTRACTS BOOK

August 6, 10:00-10:30 - Morning Poster Session S 390-1

Purely Facular MgII Index

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The MgII index has emerged as a valuable metric for studying solar activity and its impact on the Earths atmosphere. This index focuses exclusively on the contribution of facular regions, which are bright and transient solar features associated with enhanced magnetic activity. In this study, we utilize data from the Interface Region Imaging Spectrograph (IRIS), the Helioseismic and Magnetic Imager (HMI), and the Solar Stellar Irradiance Comparison Experiment (SOLSTICE) to develop an improved MgII index that highlights the contribution of the facula. The IRIS provides high-resolution observations of the solar chromosphere and transition region, allowing us to analyze the spatial distribution and temporal evolution of facular regions. The HMI provides magnetic field measurements, enabling us to study the relationship between magnetic activity and the facular MgII index. Additionally, the SOLSTICE provides calibrated solar irradiance measurements, which we will use to correct the IRIS measurements. Our analysis will yield insights into the dynamics, variability, and potential connections of the facular MgII index with magnetic activity and solar irradiance. These findings contribute to a deeper understanding of solar phenomena and their implications for atmospheric and climate studies.

August 6, 10:00-10:30 - Morning Poster Session S 390-1

Short term variations in the solar spectrum

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The Sun's brightness fluctuates over all time scale, ranging from seconds to centuries. Short-term variations (minutes to days) are caused by convective motions in the Sun's outer layers, but long-term variations (months or longer) are caused by changes in the global magnetic field. New solar irradiance measurements from the GOES satellite allows us to better understand these short-term variations in solar brightness. Visible light is measured by the sun position sensor, several ultraviolet wavelengths are measured by the Extreme Ultraviolet Sensors, and extremely short wavelengths are measured by the Xray Sensor. Different wavelengths sample different heights in the solar atmosphere, so understanding the frequency spectrum of these variations will help to constrain models of the outer atmosphere of the Sun.

In this Masters project, we will investigate the frequency spectrum of variations in the EUVS full-disk irradiance measurements caused by solar flares. Characteristic oscillation periods in the photosphere and chromosphere are five and three minutes, respectively. Simultaneous observations from all the EUVS channels before and after strong flares will map out density variations in the solar atmosphere. I am using python to analyse and visualize the data.

August 6, 10:00-10:30 - Morning Poster Session S 390-1

On The Connection Between Solar Surface Magnetic Flux Density and Solar UV Variability.

Mbonteh Roland Ndunge

Addis Ababa University. Cameroon Astronomy and Space Research Organization.

The sun is a beautifully magnetically driven giant ball of plasma with invisible magnetic field lines spreading throughout its surface. Solar surface magnetic field is generated by a process known as solar dynamo. The strength of solar surface magnetic flux or solar surface magnetic induction or simply solar surface magnetic flux density (B) is believed to be related with solar UV variability. The best known indicator of solar variability is the records of sunspot numbers allowing direct measurement of solar radiation across different wavelengths, including the large variations in UV, the results to be presented in this document basically rely on daily sunspot datasets of 2010 and 2014 respectively taken from the World Data Center SILSO, Royal Observatory of Belgium, Brussels and are available at the SILSO website (https://www.sidc.be/SILSO/datafiles). These datasets were accessed via the LASP Interactive Solar Irradiance Datacenter (LISIRD) (https://lasp.colorado.edu/lisird/), and for the datasets of solar surface magnetic flux, results from NASA Solar Dynamic Observatory (SDO)/Helioseismic Magnetic Imager (HMI) are used. Wavelet power spectrum, Robust Correlation coefficients and Correlogram toolbox are also used for further analysis. Moreover, the relationship between solar surface magnetic flux strength and solar UV variability will be characterized.

August 6, 10:00-10:30 - Morning Poster Session S 390-1

KAPPA package: Impact Multi-Ionization and Suppression of Dielectronic Recombination on the ionization equilibria for kappa-distributions

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There is a strong theoretical support of idea that non-Maxwellian electron distributions are present in the solar corona and transition region. The kappa-distributions or distributions exhibiting high-energy tails change individual ionization, recombination and collisional excitation rates. These changes are reflected in the changes in the ionization equilibrium, populations of the energy levels and finally in line intensities.In the latest version of KAPPA package(software and database, http://kappa.asu.cas.cz/), theelectron impact multi-ionization and density suppression of dielectronic recombination into calculations of the ionization equilibria were added.Calculated synthetic spectra for different values of kappa and plasma parameters allow us to search for diagnostic opportunities of non-Maxwellian distributions from observations. We also present the successful diagnostics of kappa-distributions based on the forbidden lines and diagnostic proposal based on the Fe XVII and Fe XVIII lines in soft X-ray spectral range.Latest results show that the quiet Sun spectra are consistent with a Maxwellian distribution but spectra of coronal loops, moss, and for the transient loop observed within active region are strongly non-Maxwellian with kappa 3 or 2.

August 6, 10:00-10:30 - Morning Poster Session S 390-1

High resolution mapping of the inner heliosphere via ground-based, wide-field radio observations.

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An outstanding problem in observational space weather is the difficulty of probing the region between that covered by white-light coronagraphs (out to a few solar radii), and in-situ observations made at L1. This region, comprising almost all of the volume of the Heliosphere within 1 AU, remains only sparsely sampled by in-situ observations with very few exceptions.

Interplanetary Scintillation (IPS) is one approach to probing this volume. Earth-based observations are made of compact astrophysical radio sources. Propagation through the interplanetary medium causes scintillation (similar to stars twinkling) and measurement of these scintillation signatures provide useful proxies for solar wind density and velocity (integrated along the line of sight). Observations from established IPS observatories have been shown to improve forecasts of solar wind density and velocity at L1, both for ambient solar wind and Coronal Mass Ejections (CMEs).

In this presentation I will focus on the use of a new generation of radio telescopes for IPS observations. With their unprecedented combination of sensitivity, wide field of view, and snapshot imaging capability, these instruments measure IPS for hundreds of sources in parallel, providing a high resolution grid of IPS measurements, sufficient to reveal the existing of smaller-scale structures in interplanetary space, as well as map the morphology of interplanetary CMEs.

Finally, I will describe how a broader range of ground-based radio observations here in Australia can provide complementary information on the inner heliosphere. Such observations include observations of interplanetary spacecraft, pulsars, linearly polarised sources, and direct emission from the Sun and CMEs.

August 6, 10:00-10:30 - Morning Poster Session S 390-1

Advances in Polarimetric Imaging of the Sun at Low Radio Frequencies

Divya Oberoi[1], Devojyoti Kansabanik [2,3], Surajit Mondal [3], Soham Dey[1], Puja Majee[1], Deepan Patra[1]

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Polarization of active solar radio emissions is well known to carry a host of information about the emission mechanisms giving rise to this emission as well as the nature and topology of the local magnetic fields, which have remained notoriously hard to measure at coronal heights. For the quiet Sun, thermal emission picks up weak circular polarization in the presence of birefringent coronal plasma and can provide a coveted estimate of average quiet coronal magnetic fields. Despite these strong scientific motivations, rather limited progress has been made on this front as polarimetric imaging at low radio frequencies is technically challenging. Only comparatively recently, the confluence of the following two things has made it possible - (1) availability of data from new generation instruments like the Murchison Widefield Array (MWA), a precursor to the low-frequency telescope of the Square Kilometre Array Observatory and (2) development of dedicated interferometric radio imaging pipeline optimized for solar observations with the MWA (P-AIRCARS; Kansabanik et al., 2022, 2023). We are now using this combination to explore the polarimetric properties of not only the well-known solar bursts (types II and III) but also the quiet Sun and coronal holes. This presentation will showcase the highlights from this work, focusing on a detailed characterization of the nature of the polarized sources detected, and the implications and puzzles they lead to. This is proving to be a very interesting line of enquiry, which is expected to yield significant science results as it matures.

August 6, 10:00-10:30 - Morning Poster Session S 390-1

Investigating the origin of the fast solar wind by linking remote-sensing and in situ measurements by the ESA/NASA Solar Orbiter mission

Luca Franci[1], Alexander James[2], Eric Buchlin[3], Stephanie Yardley[1], Slimane Mzerguat[3], Clara Froment[4]

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I will present the results of a "Fast Solar Wind Connection" Solar Orbiter Observing Plan (Fast Wind SOOP) that took place in October 2023. Its scientific goal was to identify the release mechanisms of the fast solar wind by relating an observed coronal hole to the solar wind measured in situ at the spacecraft's location. We combined low-latency images by the Extreme Ultraviolet Imager onboard Solar Orbiter, Earth-perspective observations by the Solar Dynamics Observatory, and models from the Magnetic Connectivity Tool to decide the target pointing. This was chosen to be a low-latitude coronal hole, located at the predicted foot points of the fast wind that would be later measured in situ. Coordinated observation campaigns for spectroscopy and/or imaging from Earth were also conducted by Hinode, the Interface Region Imaging Spectrograph, and the Swedish Solar Telescope. I will present and discuss our analysis of remote and in-situ data and how we can use their combination to get a better understanding of the sources of the fast solar wind. Among other things, we observed an eruption in proximity of the coronal hole, associated to a type III radio burst, and a filament channel encircling most of the coronal hole, exhibiting an interesting pattern of strong upflows and downflows along its boundaries. Another instance of the Fast Wind SOOP will be run in early April 2024, and some preliminary results from this could also be available in time for the symposium.

August 6, 10:00-10:30 - Morning Poster Session S 390-1

Statistical Study of Solar Wind and Interplanetary Magnetic Field Parameters in Forbush Effects and Interplanetary Disturbances (FEID) during Solar Cycles 23 and 24 from 1996 to 2019

Onyinye Jerry-Okafor[1], Chika Onuchukwu[1], Nonso Okoli[2], Victoria Okoye[1]

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The study examines the statistical analysis of Forbush Effects and Interplanetary Disturbances (FEID) parameters across the dynamic solar cycles 23 and 24 spanning from 1996 to 2019. Forbush Effects represent the transient decrease in cosmic ray intensity observed on Earth, associated with the passage of solar ejecta through the interplanetary medium. Interplanetary disturbances, encompass a spectrum of phenomena arising from the interaction between the solar wind and the Earth's magnetosphere. The selected FEID parameters under analysis include Bmax (maximum interplanetary magnetic field intensity), VmBm (maximum velocity of solar wind), Bzmin (minimum value of Bz), BzmtoBm (ratio of Bz minimum to B maximum value), and ABzmax (the maximum absolute value of Bz component). These parameters are essential in understanding the nature and impact of solar disturbances on the Earth's magnetosphere and space weather dynamics. Employing comprehensive statistical techniques, including time series analysis, correlation analysis, and trend analysis, the study aims to elucidate the temporal variations, interrelationships, and trends exhibited by the FEID parameters throughout solar cycles 23 and 24. By analyzing nearly two and a half decades of data, the research endeavors to discern potential patterns, irregularities, and cyclical behaviors within the FEID parameters, thereby contributing to a deeper understanding of solar-terrestrial interactions and space weather forecasting. In conclusion, this research underscores the importance of systematic statistical analysis in unraveling the complexities of solar-terrestrial phenomena and underscores the need for continued monitoring and investigation of Forbush Effects and Interplanetary Disturbances across solar cycles for enhanced space weather forecasting and mitigation strategies.

August 6, 10:00-10:30 - Morning Poster Session S 390-1

Highly precise spectropolarimetry with ZIMPOL at IRSOL and at GREGOR as a tool to study the structure and evolution of solar magnetic fields

Renzo Ramelli [1], Franziska Zeuner [1], Svetlana Berdyugina [1,2], Francesco Vitali [1], Daniel Gisler [1], Michele Bianda [1], Luca Belluzzi [1,2,3]

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Observations with the ZIMPOL polarimeter at IRSOL and GREGOR telescopes benefit of recent instrumental developments that allow detecting polarization signals with an improved zero-level accuracy and a precision mainly limited by the photon noise. This opens the possibility to understand and study the structure and evolution of the most elusive magnetic fields in different solar features. This presentation overviews the instrumentation developments and the main observing programs carried out or planned with ZIMPOL at the Gregory Coud Telescope at IRSOL in Locarno and at the GREGOR telescope in Tenerife.

August 6, 10:30-12:00 - Morning Oral Session S 390-1

ASO-S and synergies with space- and ground-based assets

Beili Ying

Purple Mountain Observatory, Chinese Academy of Sciences

The Advanced Space-based Solar Observatory (ASO-S) was successfully launched in October 2022, opening the era of comprehensive solar space observation in China. The ASO-S mission is equipped with three payloads: a Full-disk vector MagnetoGraph (FMG) to measure photospheric magnetic Fields, a Hard X-ray Imager (HXI) to observe non-thermal signals from 30 to 200 keV, and a Lyman-alpha Solar Telescope (LST) to take images of the Sun and the inner corona up to 2.5 Rs in both the Lyman-alpha (121.6 nm) and visible wavebands. The primary objective of the ASO-S mission is to explore the interconnections between solar magnetic fields, solar flares, and coronal mass ejections, which can be summarized as the "1M2B" concept. After over a year of stable operation, the satellite has amassed a substantial volume of observational data, accessed through the following link: [http://aso-s.pmo.ac.cn/sodc/dataArchive.jsp]. This presentation will provide an overview of the satellite's performance, highlight some of the major scientific discoveries, and discuss the synergies between the ASO-S mission and other space- and ground-based instruments.

August 6, 10:30-12:00 - Morning Oral Session S 390-1

Synergy and Potential Science from coordinated observations with Aditya-L1 and other Observatories

Sankarasubramanian Kasiviswanathan

U R Rao Satellite Centre

Aditya-L1, an observatory class mission is currently placed at L1 to observe the Sun and local environments continuously. While Aditya-L1 alone can carry out certain unique science, coordinated observations with other space and ground based observations would enhance the knowledge about the Sun and heliophysics.

In this presentation, the potential observational capability of Aditya-L1 will be presented. Few potential areas where coordinated observations of Aditya-L1 with other observatories will provide additional science will be brought out. Both Indian and international facilities is identified for the same. The plan for the coordinated observations would also be discussed. Future potential coordinated observations which are not covered above will also be highlighted.

August 6, 13:30-15:00 - Afternoon Oral Session S 390-2

Intersecting frontiers for ground- and space-based solar missions: symbiotic coordination between DKIST, PSP, and Solar Orbiter

Thomas Schad, DKIST Team

National Solar Observatory

Three uniquely powerful solar and heliospheric facilities are now operational at the same time. The US National Science Foundation's Daniel K Inouye Solar Telescope (DKIST), NASA's Parker Solar Probe (PSP), and ESA's Solar Orbiter each represent frontiers in solar and space science, and each pursue richly tailored science missions. At the intersection of these missions, however, lies unparalleled opportunities for multi-vantage point solar science. This symbiotic relationship is especially pronounced during PSP's perihelia and Solar Orbiter remote science windows, which rally efforts amongst existing and new observational assets. Being the most advanced and largest solar polarimeter ever built, DKIST strengthens many of the driving multi-facility use cases by probing regimes previously inaccessible. In particular, DKIST opens new diagnostic windows into solar magnetism–spanning the photosphere, chromosphere, and corona—at unprecedented spatial, temporal, and polarimetric resolutions. In this talk, we report recent efforts to maximize the science potential of coordinated DKIST, PSP, and Solar Orbiter observations. Existing DKIST data from coordinated observations with Solar Orbiter and PSP will be reviewed alongside some first results achieved from these data sets.

Bridging the solar interior and the solar wind with radiative MHD modeling

Haruhisa Iijima [1], Takuma Matsumoto [1,2], Hideyuki Hotta [1], Shinsuke Imada[3]

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We will present our recent works on the three-dimensional radiative magnetohydrodynamic (MHD) simulations to investigate physical links between the solar interior and the solar wind.

The thermal convection in the solar interior is a known primary driver of the magnetic activity observed around the Sun, such as the solar wind. Recent advancements in solar observations, both in space and on the ground, have gradually unveiled the energetic link between the solar interior and the solar wind. However, the complexity of the Sun's magnetic field topology and the significant differences of spatial and temporal scales have made it challenging to fully understand the physical origins of various interplanetary phenomena.

To investigate energetic connections between the thermal convection and the solar wind formation, we carried out large-scale radiative MHD simulations using the numerical code RAMENS. The typical numerical box spans from the upper convection zone to a few tens of solar radii away from the Sun. The simulated thermal convection (from granular to super-granular scales) generated the mixed-polarity magnetic patterns through the small-scale dynamo. The interaction between the dynamo-generated magnetic field and the thermal convection spontaneously produces a millionth-degree corona and a supersonic solar wind without relying on any empirical assumptions. Through analysis of the simulated system, we could show a quantitative significance of the interchange reconnection in the solar wind acceleration. We hope our model will supplement the spatial or causal gaps between multiple observations.

August 6, 13:30-15:00 - Afternoon Oral Session S 390-2

Exploring the magnetic fields of the upper solar chromosphere via ultraviolet spectropolarimetry.

Javier Trujillo Bueno

Instituto de Astrofsica de Canarias

The magnetic field is the main driver of the spectacular activity of the solar upper atmosphere (chromosphere, transition region and corona), but its determination is notoriously difficult. This is because the observables of the solar radiation that are sensitive to the magnetic field in such relatively hot and rarefied regions of the solar atmosphere are difficult to measure and interpret. Over the last decade novel theoretical investigations based on the quantum theory of atom-photon interactions indicated that key observables for diagnosing magnetism from the photosphere to the base of the corona are the linear and circular polarization signals that the scattering of anisotropic radiation and the Hanle and Zeeman effects introduce in ultraviolet spectral lines, such as hydrogen Lyman-alpha and Mg II h and k. This led an international team (USA, Japan and Europe) to pursue the development of the CLASP suborbital space experiments, which in 2015, 2019 and 2021 have provided unprecedented measurements of the Stokes profiles in such and other ultraviolet spectral lines, both in quiet and active regions of the solar disk. This talk provides an overview of the research advances enabled by these sounding rocket experiments, which have opened a new diagnostic window in solar physics: ultraviolet spectropolarimetry.

Height-Dependent Variations in Temperature and Non-Thermal Velocity in Fan Loops

Aishawnnya Sharma [1], Durgesh Tripathi[2]

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Non-thermal velocity is an important parameter to understand the underlying physical mechanisms responsible for the solar coronal heating. In this study, we investigate how temperature and non-thermal velocity change with height in fan loops, using observations from the Extreme Ultraviolet Imaging Spectrometer (EIS) on board Hinode. Our approach involves using the emission measure (EM)-loci method to estimate the temperatures of various coronal fan loops. We then calculate the non-thermal velocities after subtracting thermal velocities obtained using the EM-loci temperatures in Si vii 275.35 A and Fe viii 185.21 A lines. The EM-loci analysis reveals nearly iso-thermal structure (log T(K)=5.855.95) of the fan loops and we obtain the non-thermal velocities in the range of approximately 515 km s^{-1} and 1129 km s^{-1} for Si vii 275.35 A and Fe viii 185.21 A, respectively.

August 6, 15:00-15:30 - Morning Poster Session S 390-2

ACCELERATION RATE OF PROTONS DURING SOLAR FLARES

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Solar proton events registered bythe anticoincidence shield of the spectrometer on the INTEGRAL (ACS SPI)during 23-25 solar cycles were considered. The proton acceleration rate was estimated from the onset of >100 keV electron emission (hard X-ray (HXR) or microwaves) and the proton onset of ACS SPI count rate. It is shown that in solar flares the rate of proton acceleration is consistent with the range of electron acceleration times up to 100 keV from tens to hundreds of milliseconds, known from HXR observations.Consequently, solar protons >100 MeV and electrons >100 keV are accelerated by the same mechanism during the development of eruptive flares.The acceleration mechanism is a stochastic acceleration by multiple reconnection during developing magnetic detonation in eruptive flares.Eruptive flares and proton events can be classified by the rate at which electrons and protons are accelerated.In this case, proton events associated with ground level enhancements of cosmic ray intensity (GLE events with p > 450 MeV) are distinguished by the early < 20 min arrival of the first protons into the Earths orbit relative to the onset of HXR radiation >100 keV (proton acceleration rate > 1 MeV/s).In late >20 min proton events, the acceleration rate is <1 MeV/s.In early proton events without GLE, there was not enough time to accelerate a sufficient number of Ep > 450 MeV protons. Rare late GLE relatively to the ACS SPI proton onset might be attributed to small acceleration rate.

August 6, 15:00-15:30 - Afternoon Poster Session S 390-2

pyCAT: a Next-Generation Re-Imagining of NOAA/SWPC's CME Analysis Tool

Mark Miesch [1], Manasi Gopala [2], George Millward [1], Charlotte Martinkus [1], Anders Englyst [3], Mike Marsh [3], Francois-Xavier Bocquet[3]

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The first operational numerical model to leverage high-performance computing (HPC) resources at NOAA's Space Weather Prediction Center (SWPC) was the WSA-Enlil model, a composite semi-empirical/MHD model of the solar wind. The WSA-Enlil model was made operational in 2012 and is still used today to forecast the arrival time of coronal mass ejections (CMEs). One of the motivations of this transition to operations was the availability of multi-perspective coronagraph observations from NASA's STEREO mission (launched in 2006). However, to leverage these assets, there had to be a way to assimilate coronagraph observations into the WSA-Enlil model. This led to the development of SWPC's CME Analysis Tool (CAT), written in IDL. The CAT allows SWPC forecasters to fit multi-perspective coronagraph observations to idealized cone models of CMEs which can then be ingested into Enlil. NOAA/SWPC and the United Kingdom Met Office (UKMO) are now developing a modernized version of CAT called pyCAT that features an interactive browser-based front end, a python back end, and an event database managed by MongoDB. After initial development and deployment, we plan to make pyCAT available as an open-source application to promote Research to Operations and Operations to Research (R2O2R). In this talk I will describe the motivation, design, and expected use of pyCAT and encourage the community to participate as users and potentially contributors. The goal is a modern, containerized, user-friendly, extensible application for modeling CME events that can be progressively improved to leverage future advances in multi-perspective observing platforms and numerical modeling.

Solar Orbiter/EUI Observations and Bifrost MHD Simulatons of Fine-scale Bright Dots in Emerging Flux Regions

Sanjiv Tiwari [1,2], Viggo Hansteen [1,2], Bart De Pontieu [1], Navdeep Panesar [1,2], David Berhgmans[3]

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Solar Orbiter's EUI/HRIEUV observations of an emerging flux region (a typical EUV/X-ray bright point) in 174A reveals the presence of numerous tiny bright dots. These dots are roundish with an average diameter of 675 km, a lifetime of 50s, and an intensity enhancement of 30% from their immediate surroundings. About half of the dots remain isolated during their evolution and move randomly (<10 km/s). The other half show extensions, appearing as a small loop or surge/jet, with intensity propagation < 30km/s. Many of the bigger HRIEUV dots are discernible in SDO/AIA 171A, have significant EM in the T-range of 1-2 MK, and are often located at polarity-inversion-lines observed in HMI LOS magnetograms. The Bifrost MHD simulations of an emerging flux region do show dots in synthetic Fe IX/X images, although dots in simulations are not as pervasive as in observations. The dots in simulations show distinct Doppler signatures - blueshifts and redshifts coexist, or a redshift of $\sim$10 km/s is followed by a blueshift of similar or higher magnitude. Our results, together with the field geometry of dots in the simulations, suggest that most dots in emerging flux regions form in the lower solar atmosphere (at $\sim$ 1 Mm) by magnetic reconnection between emerging and pre-existing/emerged magnetic field. The dots are smaller in Fe IX/X than in O V/VI, and Si IV lines ikely because only the hottest counterpart of magnetic reconnection events is visible in the hotter emission.

Observations of kink-and-dissconnection solar failed eruption: 3D perspective.

Tomasz Mrozek [1,2], Zhentong Li [3], Marian Karlicky [3], Nicolina Chrysaphi[5]

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We report first stereoscopic observations of HXR emission sources registered by STIX onboard Solar Orbiter and HXI on ASO-S. This is a case study of two-stage failed eruption. First, it was stopped due to kink instability. However, kinked structure started to reconnect in the X-point and second stage of eruption started. This eruption was failed few minutes later due to reconnection below the magnetic flux rope and confinement by overlying magnetic fields. We identified three X-ray sources located in the corona which are related to reconnection site, and to the magnetic cloud arrested by overlying fields. Combining stereoscopic X-ray observations from STIX and HXI (31.5 degrees vantage point separation) together with Differential Emission Measure (DEM) maps based on SDO/AIA observations we were able to locate X-ray sources sites in the corona in the 3D space. The completness of the observed features was achieved by adding radio observations from STEREO/Waves. Results and further perspectives of stereoscopic observations of CMEs initiation (or failure) will be discussed.

Triple coronal Hard X-Ray source observed by STIX during a failed eruption of a filament.

Tomasz Mrozek [1,2], Marek Steslicki [1], Sylwester Kolomanski [2], Krzysztof Barczynski[3,4]

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Solar Hard X-Ray (HXR) emission is observed typically in the form of localized, rather compact sources. Majority of previously observed HXR sources are flare related, however there is growing evidence, observational and theoretical, that we can expect HXR emission from places not directly related to primary energy release regions. From this point of view, failed eruptions are very promising. There are only a few observations, from past instruments, showing some evidence of HXR production in failed eruptions. Recently, the Solar Orbiter has been launched giving a completely new perspective for observation and analysis of coronal dynamic events. Apart from others, it carries onboard Extreme-Ultraviolet Imager (EUI) and Spectrometer/Telescope for Imaging X-rays (STIX) telescopes open an opportunity to understand the physics of failed eruptions. Here, we present a case study of a very well observed flare accompanied by a failed eruption. From the Earth (AIA) perspective the event was visible very close to the west limb of a solar disc. For Solar Orbiter it was a behind-the-limb event with occulted footpoints which gave us a very good view, especially in the HXR range, of emission coming from the solar corona. During a flare's impulsive phase, the eruption accelerated to the velocity of a few hundreds kilometers per second and after six minutes it stopped abruptly at the height of 100 000 km above the solar surface. The eruption reconnected with overlying coronal loops leading to occurrence of at least three HXR regions observed by STIX.

Surface flows prior to active region emergence on the Sun

Hannah Schunker [1], Camron Alley [1,2]

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Understanding the physics of how magnetic active regions on Sun form and evolve at the surface will improve space weather forecasting. On average, it has been shown that active regions prefer to emerge in converging flows. We identified a sample of 42 emerging active regions (EARs) associated with small magnetic bipoles at least one day before the time of emergence in the Solar Dynamics Observatory Helioseismic Emerging Active Region survey (Schunker et al. 2016, A&A. 595, A107). We then identified a contrasting sample of 42 EARs that emerge more abruptly. We computed the supergranulation-scale surface flows using helioseismic holography, and averaged the flow maps and magnetic field maps over all active regions in each sample over the emergence time. We found that EARs associated with a persistent pre-emergence bipole evolve to be, on average, lower flux active regions than EARs that emerge more abruptly. Our results show that there is a statistical dependence of the surface flow signature throughout the emergence process on the maximum magnetic flux of the active region.

Quasi-periodic oscillations of flare loops and slipping motion along flare ribbons during a C-class flare

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Quasi-periodic oscillations are commonplace in many flares. To date, the underpinning processes resulting in the quasi-periodic oscillations remain unknown. In this paper, we report a unique event that exhibits both the long-duration quasi-periodic intensity oscillations of the flare loops and the quasi-periodic slipping motion of ribbon substructures during a C9.1 class of SOL20150315-T01:15, using the observations from Solar Dynamics Observatories and Interface Region Imaging Spectrograph. The high-temperature flare loops rooted in the straight part of the ribbons display "bright-dim" intensity oscillation, with a period of about 4.5 minutes. The oscillation starts just after the flare onset and lasts over 3 hours. Meanwhile, the substructures within the ribbon tip display the quasi-periodic slipping motion along the ribbons at 1400 Å images, with the similar period of the stationary intensity oscillation of flare loops at the straight part of flare ribbons. We suggest that the quasi-periodic pattern is probably caused by the interaction of the intermittent reconnection outflows and flare loops.

August 6, 15:00-15:30 - Afternoon Poster Session S 390-2

Global Solar Activity Data Portal for Studying 3D Dynamics and Activity of the Sun

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The main problems with understanding and predicting solar activity are tightly linked to limitations in describing the global evolution of the Sun from the deep interior to the corona. Because of the complexity of interactions in a wide range of dynamical, turbulent, and spatial scales and dramatic changes in thermodynamic and magnetic field conditions, only physics-based models can provide essential background to generate reliable solar activity forecasts. However, performing accurate model calibration and estimating uncertainties is often challenging due to the unavailability of a long time series of observations. To mitigate these limitations, we have developed the Global Solar Activity (GSA) Data Portal, which enables convenient access to a variety of modern and historical data. The portal supports a dynamic visualization for 1D time series (such as the sunspot number and solar irradiance) and quick-look visualization for 2D data sets (e.g., synoptic magnetograms, the solar internal rotation, and flows). The GSA portal includes a search engine that enables data retrieval from user-specified data sources and time intervals. In this presentation, we will discuss the current and upcoming capabilities of the data portal and its potential applications for space weather studies.

August 6, 15:00-15:30 - Afternoon Poster Session S 390-2

Development of Solar Flare and Energetic Particle Prediction Portal (SEP3)

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Solar activity is a primary factor determining the state of the Earths space environment, geomagnetic and ionospheric disturbances, and radiation hazards. In the current state of knowledge, machine learning (ML) methods provide essential tools for processing data, investigating relationships among various physical properties and characteristics, uncovering hidden connections, and predicting hazardous solar events. The primary difficulty in developing and applying modern machine-learning tools in heliophysics is that the essential data are scattered among over a hundred data repositories developed by instrument teams of space missions and ground-based observatories. In addition, statistical and ML methods require long time series of homogeneous measurements. To facilitate ML-ready data preparation and access, we have developed an interactive database of solar flares integrating the most essential datasets (https://solarflare.njit.edu/ [https://solarflare.njit.edu/]). The database performs an initial data processing and is automatically updated. In addition, we are developing the Solar Energetic Particle Prediction Portal (SEP3, https://sun.njit.edu/SEP3 [https://sun.njit.edu/SEP3]), which hosts web applications that allow users to retrieve the database records. The Portal has a search page for browsing the events from the most widely used catalogs and a dedicated space to share the most recent achievements of the team. The interactive widget can display soft X-ray and proton flux time series from GOES satellites and the flare records. The data portal has been used to evaluate the forecasts of solar proton events and investigate machine-learning approaches to SEP prediction.

August 6, 15:30-17:00 - Afternoon Oral Session S 390-3

Sources of the slow solar wind and the role of the coronal magnetic field topology

Lucia Abbo

INAF-Astrophysical Observatory of Turin

In order to investigate the sources and the physical mechanisms for the propagation of the Slow Solar Wind (SSW), it is essential to analyze and modeling solar data in the region which determines the large scale structure in corona and also the origin of the SSW (from the solar disk up to 5 solar radii). It will be given an overview of recent results by Solar Orbiter observations together with other space missions (i.e. SPP and GOES) which have contributed to the study of the global corona together with the role of the coronal magnetic field topology in controlling the solar wind dynamics and composition. We discuss also the results by the Total Solar Eclipse data, the possible future observations by PROBA-3 and by Solar Orbiter from 2025 when is out-of-ecliptic plane.

August 6, 15:30-17:00 - Afternoon Oral Session S 390-3

Energization of Alfvnic slow speed solar wind

Yeimy Rivera [1], Samuel Badman [1], Tamar Ervin [2], Enrico Landi [3], John Raymond [1], Katharine Reeves [1], Michael Stevens [1], Soumya Roy [1], Tania Varesano[4]

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A complete theory of the solar wind requires an effective connection between where solar wind originates, how it forms, and how it evolves once it escapes the corona. Decades of remote and in situ observations have found that winds from different coronal sources behave differently as characterized by their properties in the corona and at large heliocentric distances, i.e., bulk speed, density, temperature, heavy ion composition, Alfvnicity. Recent work suggests that the fast and slow wind are energized by different mechanisms ions in the slowest wind are accelerated through the ambipolar potential while ions in the fastest speed wind require additional heating and acceleration by Alfvn waves. A distinct subset of the slow solar wind exhibits high Alfvnicity and distinct heavy ion composition signatures. The subgrouping suggests such streams have a distinct source and radial evolution profile compared to conventional fast and slow outflows. Through a conjunction with Parker Solar Probe and Solar Orbiter, combined with near-synchronous spectroscopic remote observations, this work examines the large-scale energetics in Alfvnic slow wind compared to slow solar wind from a current sheet crossing to understand if/how they differ. The talk will also discuss theimportance of ongoing integrated remote and in situ observations from present/newly operational solar telescopes that are necessary for addressing open questions about our starand its space weather impacts.

August 6, 15:30-17:00 - Afternoon Oral Session S 390-3

Solar wind near coronal streamer structures using 3D MHD simulations in spherical geometry

Piyali Chatterjee

Indian Institute of Astrophysics

We use 3D MHD model in spherical geometry to understand the dependence of solar wind properties near a coronal streamer by varying the magnetic field and in-situ volumetric heating. The model additionally includes anisotropic heat conduction along field lines, optically thin radiative cooling and a semi-relativistic correction to Lorentz force. Our final aim is to understand the coronal flux rope activation or CME initiation conditions in presence of the ambient magnetic field that has been stretched by the solar wind. This kind of topology is close to H-alpha polar crown filaments observed on the Sun during migration of poloidal flux of the new cycle to the solar poles.

August 6, 15:30-17:00 - Afternoon Oral Session S 390-3

Estimation of projection effects in near-limb solar manetic flux measurements: Advantage of Multi-viewpoint Observations

Sanjay Gosain

National Solar Observatory

We demonstrate using controlled MHD simulations that the projection effects and foreshortening cause systematic biases in the magnetic flux measurements away from the disk center, which deteriorate as one approaches closer to the solar limb. However, we show that using multiviewpoint observations of the Sun can help in overcoming these systematic effects. We evalute the extent of such effects and how cross-calibration of multi-viewpoint observatories is crucial for such combined data analysis.

August 7, 10:00-10:30 - Morning Poster Session S 390-3

Preliminary results from Solar Orbiter Eruption Watch campaigns

Clementina Sasso [1], Federico Landini [2], Giuliana Russano [1], Frédéric Auchere [3], David Berghmans [3], Éric Buchlin [3], Johann Hirzberger [5], Phil Hess[6], Säm Krucker[7], David Orozco Suárez8, Susanna Parenti [3], Luciano Rodriguez [3], Hanna Strecker[8], Gherardo Valori [5], Angelos Vourlidas[9], Anik De Groof[10], David Williams[10]

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We present preliminary results obtained in different Solar Orbiter coordination campaigns aimed to catch eruptive events. These campaigns involve all the remote sensing instruments on-board the spacecraft so to have the opportunity to follow the eruption from the onset till the outer corona. We want to perform a statistical analysis on the observed events and investigate the physical and dynamical properties of at least one case study eruption.

August 7, 10:00-10:30 - Morning Poster Session S 390-3

Recurrent Eruption and Formation of a Flux Rope by Flux Cancellation

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The primary mechanism considered for the creation of magnetic flux ropes in the solar corona, during its quasi-static evolution between eruptions, involves the cancellation of magnetic flux in the photosphere. This process is believed to not only form flux ropes but also energize them, often leading to their eruption. Flux cancellation occurs intermittently, involving dispersed flux patches, and is typically sustained over extended periods. During such periods, a sequence of homologous eruptions is sometimes observed, with one or more confined eruptions often culminating in a final full eruption, such as a Coronal Mass Ejection (CME).In our work (Hassanin et al. 2022), we present the first Magnetohydrodynamic (MHD) simulations of flux rope formation and eruption specifically addressing homologous eruptions. These simulations depict a series of eruptions, starting with a confined eruption followed by a CME. While our modeling of the confined eruption is still simplistic, beginning with a kink-unstable flux rope in a sufficiently strong ambient field, the end state reveals a reformed, weakly twisted flux rope, indicating a potential path to homologous eruptions. Prescribed photospheric flows at the PIL, coupled with enhanced magnetic diffusion at the PIL, energize this configuration, leading to a second eruption initiated by the torus instability. Surprisingly, the new flux rope, rather than the reformed one, carries the main part of the free magnetic energy and becomes unstable. Future simulations will aim to fully drive a series of homologous eruptions solely through flux cancellation, as suggested by observations.

August 7, 10:00-10:30 - Morning Poster Session S 390-3

A multi-view study of consecutive CMEs observed by SoloHI during March 2022

Cecilia Mac Cormack [1,2], Cristina Mandrini [3], Laura Balmaceda[4,2], Shaheda B. Shaik [3], Germn Cristiani [3], Phillip Hess [5], Robin Colannino [5], Teresa Nieves-Chinchilla[2],

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With the new solar missions, we have integrated high-resolution instruments that are able to fill some pre-existing gaps by providing observations closer to the Sun and out of the ecliptic (e.g. Solar Orbiter). These observations are crucial to understand the CME evolution from their origin until 1 au.The Solar Orbiter Heliospheric Imager (SoloHI) onboard the Solar Orbiter mission provides higher-resolution white-light images that allow us to track specific features detected before the CME erupts through the solar corona and the heliosphere. Previous studies found a moderate to strong correlation between the kinematic properties of a CME and the magnetic properties of the active region (AR) where the CME originated.In this work, we perform a study on the magnetic evolution of the Earth-facing AR 12795 during the period March 24 - April 02, 2022. This single AR presents high magnetic activity and has produced four consecutive CMEs in late March. All the CMEs were detectedby the SoloHI onboard the SolO mission. By combining SoloHI data with other remote sensing observations located at 1 au, we can perform a multi-viewpoint analysis that can describe the global picture of the early evolution of a CME from its origin.We present preliminary results of this analysis, performing a 3D reconstruction and correlating it with the flux emergence and magnetic evolution of the AR.

August 7, 10:00-10:30 - Morning Poster Session S 390-3

Si IV emission model of the response of the flare energy transport through the transition region

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Results of the Si IV emission modelling at the footpoints of flaring loops are presented. The radiation-hydrodynamical simulations were performed using the FLARIX code. We modelled time dependent plasma parameters (temperature, density, non-Maxwellian beam electron distribution function...) in the transition region. They are response to an electron beam transport of energy from reconnection site down to the chromosphere. We tested a wide range of the beam parameters. Consequently, non-equilibrium ionization states for non-Maxwellian distributions of silicon and Si IV emission were calculated with high temporal resolution. The results are then compared with Si IV emission observed by IRIS during the impulsive phase of solar flares.

August 7, 10:00-10:30 - Morning Poster Session S 390-3

Probing the dynamical properties of new sub-type III solar radio burst (type VI)

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MARA University of Technology (UiTM), Malaysia

Solar radio bursts (SRBs), including the newly identified type VI within the sub-type III category, are intriguing phenomena occurring in the solar atmosphere. These bursts exhibit unique dynamical properties, yet their detailed characteristics and relationship with other solar activities have not been explored extensively. This study aims to investigate the dynamical properties of sub-type III solar radio bursts and uncover their underlying mechanisms of generation and propagation. Through meticulous analysis of observational data, we seek to understand the temporal evolution, spectral characteristics, and spatial distribution of these bursts. Additionally, we aim to explore potential correlations with other solar phenomena such as solar flares, coronal mass ejections (CMEs), and sunspot numbers. We conducted a comprehensive analysis of observational data from 2020 until 2024 acquired from e-CALLISTO, a worldwide network of solar radio spectrometers. Signal processing techniques that include time-frequency analysis and statistical methods were employed to identify patterns in burst morphology and variations in dynamical properties. Comparative analysis allowed us to explore potential correlations between the bursts and concurrent solar activities. Our analysis reveals intricate patterns in the dynamical properties of sub-type III solar radio bursts. We observe distinct temporal evolution, spectral signatures, and spatial distributions indicative of complex underlying processes. Additionally, our preliminary findings suggest complex interactions between SRB type VI and other solar activities, indicating possible links to magnetic reconnection processes and energy release mechanisms. In conclusion, this study enhances our understanding of the dynamical properties of SRB type VI and their implications for solar dynamics and space weather.

August 7, 10:00-10:30 - Morning Poster Session S 390-3

Time evolution of Thermal and Non-thermal Energies in two Solar Flares

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We examine two solar flares, specifically an X-class event occurring on October 28th, 2021, and an M-class event on November 29th, 2020, to understand the dynamic variations in thermal energy throughout their progression. Our analysis incorporates data from various sources such as the Atmospheric Imaging Assembly (AIA) on the Solar Dynamics Observatory (SDO), the Hinode X-ray Telescope (XRT), and the Spectrometer/Telescope for Imaging X-rays (STIX). Utilising this data, we estimate the overall thermal energy for both flares by calculating the Differential Emission Measure (DEM) to track thermal energy changes over time. Additionally, we use spectra from the STIX instrument onboard the Solar Orbiter for the X-class flare to estimate the non-thermal component. We also explore the impact of volume estimates of the flare arcade over time on our thermal energy calculations, underscoring the importance of high-resolution imaging across various wavelengths and perspectives. We propose a method for precisely determining the Line of Sight (LOS) throughout the Field of View (FOV) using near-simultaneous observations from multiple viewpoints, resulting in a better estimate of the volume of the flare arcade. Furthermore, our investigation of the M-class event includes an analysis of the thermal structure of the fan in comparison to the overall thermal evolution of the flare. Our findings reveal that the thermal energy decay of the fan is slower than that of the flare loops, suggesting a distinct heating mechanism at play within the fan structure.

August 7, 10:00-10:30 - Morning Poster Session S 390-3

First robust detection of linear polarization from solar radio bursts

Soham Dey [1], Devojyoti Kansabanik [2,3,1], Surajit Mondal [3], Divya Oberoi[1]

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When studying the polarimetric solar radio emissions, the focus has exclusively been on circular polarization. This originated from the reasonable expectation that even in the unlikely event that linearly polarized emission existed, the significant differential Faraday rotation in the coronal plasma should obliterate it (e.g., Grognard & McLean, 1973). Hence, despite some reports of detections of linear polarization in the late 1950s and early 1960s, the consensus has been to reject any linear polarization found in the observed dynamic spectra as instrumental artifacts (e.g., Grognard & McLean, 1972). This belief is so deeply rooted that it is routinely used during calibrating solar polarimetric observations. The recently developed full polar radio interferometric calibration algorithm, P-AIRCARS (Kansabanik et al., 2022a, 2022b, 2023) does not rely on this assumption. It provides state-of-the-art high-fidelity and high dynamic-range spectropolarimetric snapshot solar radio images using data from the Murchison Widefield Array (MWA). We find robust imaging-based evidence for the presence of linearly polarized emission during active solar emissions. We have also confirmed its presence using simultaneous observations from the MWA and the upgraded Giant Metrewave Radio Telescope at overlapping frequencies. We find that the Rotation Measure associated with this linearly polarized signal is orders of magnitude less than that expected from the corona, which implies that the linear polarization must originate at much larger coronal heights. We also present our explorations of physical scenarios which can give rise to it.

August 7, 10:00-10:30 - Morning Poster Session S 390-3

Characterization of the source regions of high-latitude CMEs

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In recent decades, instrumentation dedicated to solar and heliospheric observations has proliferated, with ever-increasing temporal, spatial and spectral resolution. In spite of many of these efforts being oriented to gain knowledge about the threatening phenomenon of coronal mass ejections (CMEs), there are many pending questions on their nature and evolution. In this study, we focus on exploring relationships between CME properties and the characteristics of their source regions. To this end, we analyze the sources of high-latitude CMEs for which their morphological characteristics can be estimated with less uncertainties than typically possible. We rely on observations of different regimes of the solar atmosphere, provided by the STEREO, SOHO, and SDO missions. In the low corona and chromosphere, we characterize associated filaments and phenomena related to the eruption; while in the photosphere we investigate a number of magnetic parameters and neutral line properties. The joint analysis of source regions and CMEs enables studying how the magnetic properties and observable attributes of the source regions impact the morphological and dynamical characteristics of CMEs, which ultimately may lead to improved space weather forecasting capabilities and understanding of processes involved in the initiation and early evolution of CMEs.

August 7, 10:00-10:30 - Morning Poster Session S 390-3

Multi-viewpoint Coronal Mass Ejection catalog: Testing the pipeline for a citizen science project.

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Coronal mass ejections (CMEs) are the strongest drivers of variability in the heliosphere. Identifying events that could have an impact on spacecraft or planets is extremely important in order to protect the missions against damages and to predict catastrophic events that may imply danger for instruments, astronauts and our planet. For this reason, the operation stage of an investigation is crucial to detect solar activity and follow the CME evolution at different distances from the Sun. This task is extremely time consuming but does not require any specific expertise in the field. Therefore, this is a perfect opportunity to connect society with science and to raise awareness of space weather to the general population. With the large amount of observations and catalogs available online, and basic information on what to look for, everyone can contribute to a collaborative catalog. We perform multi-view and multi-point analysis to understand the global evolution of CMEs predicted to impact different spacecraft or planets. In this project we catalog six events that occurred in the first half of 2023. These events were detected by both, in situ and with remote instruments. The entire analysis was performed as a final project of a highschool student, and sets the basis for a larger project for the general public.

August 7, 10:00-10:30 - Morning Poster Session S 390-3

A closer look at Streamer Blowout Coronal Mass Ejections: Multi-view analysis of morphology and kinematics

Leonardo Di Lorenzo [1], Fernando López [2], Hebe Cremades [2,4], Laura Balmaceda [3], Dana-Camelia Talpeanu [5], Elke D'Huys [5], Marilena Mierla [5,6]

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We investigate three coronal mass ejections (CMEs) that occurred in 2013 and exhibit characteristics of streamer blowouts (SBOs). They often exhibit a prolonged expansion phase, indicated by an increase in the width of the lower part of the streamer. The swelling can last for several hours or days and is followed by the slow eruption of a CME at the streamer location. Their frequency varies between 1 and 12 per month, depending on the solar cycle, SBO-CMEs have been scarcely studied. This leaves unanswered questions about their origin, characteristics, and correlation with solar atmospheric structures. Moreover, the nature of these events poses important challenges for their detection, for which multi-viewpoint observations at different coronal heights are crucial. Using observations from SOHO/LASCO, STEREO/SECCHI COR1 and COR2, SDO/AIA and HMI, and PROBA-2/SWAP, we meticulously describe the evolution of the three studied events from 1 to 15 solar radii. We determine the morphology and kinematics of SBO-CMEs in terms of their three-dimensional (3D) location, velocity and acceleration. We focus on their early stages and evolution in the corona. In addition, we use a Potential Field Source Surface (PFSS) model to examine the magnetic field configuration in the region of the events. Our analysis aims to unravel the 3D morphology of SBO-CMEs in the low corona, their evolution into the middle corona, and their impact on the configuration of the surrounding magnetic field. The results provide a more comprehensive understanding of SBO events and shed light on their intricate nature.

Sunspot 3-Min Umbral Oscillations: A Statistical Perspective from GST Observations

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The Sun's dynamic atmosphere presents a diverse array of magnetohydrodynamic (MHD) waves, especially within areas of intense magnetic fields such as sunspots, where the most notable and powerful waves emerge. These waves propagate across the sunspot region, causing significant oscillations in spectral intensity and velocity. Our study focuses on observing the oscillations in the sunspot umbra using data from the Goode Solar Telescope (GST) at the Big Bear Solar Observatory. We analyze intensity oscillations at the center and the wings of the Hα line, as well as the Doppler velocity of the Hα line. Employing a wavelet analysis tool helps us identify the periodicity of the intensity and velocity oscillations. Through statistical analysis, we ascertain the prevalence of 3-minute oscillations in the umbral region. To distinguish wave modes at various wavelengths, we conduct phase difference analysis, estimating the phase difference between intensity in different bandpasses (such as Hα line core, Hα0.2, Hα0.4, Hα0.6, Hα0.8, and Hα1) and Doppler velocity oscillations. The statistical distribution of phase differences falls within the range of -180 to 180 for all bandpasses, with peaks at 0 for blue shift bandpasses, -47 for Hα, and 180 for redshift bandpasses. This suggests evidence of both upward and downward propagating waves in the chromosphere region, indicating that the characteristic 3-minute umbral oscillations are indicative of resonant modes within the sunspot.

August 7, 10:30-12:00 - Afternoon Oral Session S 390-4

Improving the Medium-Term Forecasting of Space Weather: A Big Picture Review

Angelos Vourlidas

Johns Hopkins University Applied Physics Laboratory

Our scientific understanding of the key solar drivers of Space Weather (SWx)Coronal Mass Ejections (CMEs) and tier associated flares and solar energetic particles (SEPs)has improved considerably in the last 20+ years thanks to a plethora of space missions and modeling advances. Yet, there has been relatively little progress in actionable forecasting of the geo-effectiveness of a given CME and associated phenomena. Why is that? What are the issues that are holding back progress in medium-term forecasting (hours to days) of Space Weather?

In this talk, I review the last 20+ years of research on solar drivers and identify lessons-learned and paradigm shifts in our view of the SWx-relevant solar activity. I also identify the main open questions and offer possible mitigation strategies for achieving actionable medium-term forecasting of SWx.

Measuring Magnetic Fields of Coronal Mass Ejection in Corona and Inner Heliosphere using Wide Field of View Spectropolarimetric Radio Imaging

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Measurements of the plasma parameters of Coronal Mass Ejections, particularly magnetic fields entrained in the CME plasma, are crucial to understanding their propagation, evolution, and geo-effectiveness. However, estimating magnetic fields inside the CME both at the corona and heliosphere is challenging. Several observational probes at radio wavelength can estimate CME magnetic fields in the corona and heliosphere. Spectralpolarimetric modeling of gyrosynchrotron (GS) emission from CME plasma has long been regarded as one of the most promising remote observation techniques for estimating spatially resolved CME plasma parameters. With the data from the Murchison Widefield Array (MWA) and the recently developed spectropolarimetric snapshot imaging pipeline optimized for this data (P-AIRCARS), spectropolarimetric detection of faint GS emissions has become possible. We present studies of spectropolarimetric modeling of GS emissions, demonstrating that degeneracies between several model parameters can be broken using polarimetric imaging. However, this methodology is only useful to measure CME magnetic fields up to 10 solar radii. At higher coronal heights and inner heliosphere, CME magnetic fields can be estimated by measuring the Faraday rotation of linearly polarized galactic/extragalactic radio sources. We have recently started exploring the FR measurements due to CME using the MWA. The advantage of using the MWA is its wide FoV and lower observing frequency. Lower observing frequency provides sensitivity to smaller magnetic fields and wide FoV will provide simultaneous measurements along multiple LoSs enabling estimation of magnetic fields of CMEs. We present the challenges to achieve these goals and some initial results.

August 7, 10:30-12:00 - Afternoon Oral Session S 390-4

Models for Long-Term and Short-Term Flare Prediction

Marianna Korsos

University of Catania

The integration of long-term and short-term solar flare predictions is a crucial component of space weather forecasting, given their potential impacts on Earth's technological infrastructure and astronaut safety. This presentation examines the importance of combining different long-term and short-term solar flare prediction methods to improve the reliability and precision of forecasts. Long-term predictions provide a broad understanding of solar activity, facilitating better preparedness for heightened periods of solar activity. In contrast, short-term predictions are based on recent solar observations and the rapidly evolving phenomena on the solar surface, offering warnings within hours or a daily timeframe. By merging long-term and short-term insights, a more robust and effective solar flare prediction framework can be established. This comprehensive approach enhances the accuracy of specific flare event predictions and significantly advances our grasp of solar dynamics.

August 7, 10:30-12:00 - Afternoon Oral Session S 390-4

The Magnetic Origin of Solar Campfires: Solar Orbiter and SDO Observations

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Solar campfires are small-scale coronal brightenings, observed in 174 images by EUI on board Solar Orbiter (SolO). Here we investigate the magnetic origin of different types of campfires, in quiet-Sun, using line-of-sightmagnetograms from SDO/HMI together with EUV images from SolO /EUI and SDO/AIA. We find that (i)campfires are rooted at the edges of photospheric magnetic network lanes; (ii)most of the campfires reside above neutral lines and 77%of them appear at sites of magnetic flux cancelation between the majority-polarity magnetic flux patch and a merging minority-polarity flux patch, with a flux cancelation rateof ?1018Mx hr?1; some of the smallest campfires come from the sites where magnetic flux elements were barely discernible in HMI; (iii) in the large majority of instances (79%), campfires are preceded by a cool-plasma structure,analogous to minifilaments in coronal jets; and (iv) although many campfires have complex structure, most campfires resemble small-scale jets, dots, orloops. Thus, campfire is a general term that includes different types of small-scale solar dynamic features. They contain sufficient magnetic energy (?10261027erg) to heat the solar atmosphere locally to 0.52.5 MK. Our observations suggest that the presence of magnetic flux ropes may be ubiquitous in thesolar atmosphere and not limited to coronal jets and larger-scale eruptionsthat make CMEs; and magnetic flux cancelation, most likely driven bymagnetic reconnection in the lower atmosphere, is the fundamental process for the formation and triggering of most campfires. Finally, we compare jet-like campfires with those found in a Bifrost MHD simulation.

Can the Geostationary Operational Environmental Satellite's (GOES) ultraviolet measurements predict the X-ray properties of solar flares?

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Solar flares are powerful phenomena with significant implications for space weather. Understanding their characteristics and predicting their behaviour is crucial for mitigating potential risks and ensuring the safety of space-based operations. This research project aims to investigate whether ultraviolet (UV) measurements obtained from the Geostationary Operational Environmental Satellite (GOES) can be used to predict the X-ray properties of solar flares. By analysing high-cadence UV solar spectral irradiance data from the GOES Extreme Ultraviolet and X-ray Sensors (EXIS) instrument, the study seeks to establish a reliable relationship between UV observations and X-ray flare behaviour. The ultimate goal is to develop a model that enables real-time prediction and interpretation of solar flares, empowering space weather forecasters to make accurate forecasts and take necessary precautions.

August 7, 13:30-15:00 - Afternoon Oral Session S 390-5

Multi-view and multi-point CME Catalog based in SoloHI observations

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With the combination of in-situ instruments and high-resolution remote sensing observations, the Solar Orbiter (SolO) mission has become one of the most valuable missions to study the inner heliosphere.The Solar Orbiter Heliospheric Imager (SoloHI), onboard SolO, is one of the new generation of heliospheric imagers with a field of view of 40 to the east of the Sun. SoloHI presents higher resolution than the previous generation of heliospheric imagers on board the Solar-Terrestrial Relations Observatory (STEREO) mission (HI 1-2).With SolO predicted to reach a minimum perihelion of 0.28 AU and an inclination angle of at least 30 degrees above the ecliptic plane, SoloHI complements and fills gaps in the observations of other remote sensing instruments at 1 au.

In this work, we present a living catalog of SoloHI events compiled over a span of two years of SoloHI observations. We identify each CME and present all the available remote sensing and in situ observations from other spacecraft. We also describe the source active region and provide the primary details of it. Finally, we complement the observations with the results of the WSA-ENLIN+CONE model performed by the Space Weather Database Of Notifications, Knowledge, Information (DONKI) developed at the Community Coordinated Modeling Center (CCMC).

August 7, 13:30-15:00 - Afternoon Oral Session S 390-5

Characterising solar eruptions through data-constrained MHD simulations

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Solar eruptions are ubiquitous in the sun and are one of the leading actors of space weather. The multiview observations have provided not only a three-dimensional reconstruction of coronal mass ejections but also new insights into their initiation processes. Motivated by what drives eruptive processes and to better understand the coupling between active region magnetic topology and thermodynamical variables, we develop a numerical framework for modelling ARs evolution. We consider different extrapolation techniques based on an HMI magnetogram. Here, I will present the results of an eruption that occurred in NOAA AR 12241 on December 18, 2014. We find that a flux rope self-consistently develops and rises in all our simulations. With the aid of an algorithm that identifies and tracks this structure, we study how the different extrapolation cases influence the dynamics of the magnetic flux rope. Taking advantage of the 3D simulations, we also reproduce synthetic EUV emissions from different points of view that can be directly compared with observations. We also add test particles to the model to identify particle acceleration sites and predict the shape of the hard-X ray emission. This work takes us a step closer to understanding the eruptivity of a given active region and the processes involved during the eruption. Hence, it improves our predictive and forecasting abilities for space weather purposes.

August 7, 13:30-15:00 - Afternoon Oral Session S 390-5

Magnetic Field Properties of Solar Sources of Impulsive Solar Energetic Particle Events

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Impulsive solar energetic particle (SEP) events show unusual elemental composition with ^{3}He and ultra-heavy ions enhanced by factors up to 104 above the coronal abundance. This results from yet-unknown acceleration mechanisms during magnetic reconnection in flares or jets. We identified 20 high-energy, impulsive SEP events in solar cycle 24 with 10 MeV/nucleon ^{3}He abundance >103 times the coronal value using SIS on ACE. The AIA SDO observations determined the associated solar sources. We explored the influence of parent active region (AR) magnetic properties on heavy-ion enrichment and intensity. Specifically, we used the magnetic class and the area from the NOAA Solar Region Summary. Complex ARs tend to show a higher ^{3}He/^{4}He ratio. In addition, both ^{3}He/^{4}He and ^{3}He intensity moderately correlate with AR area. We also used SHARP (Spaceweather HMI Active Region Patches) parameters obtained from the JSOC/Stanford repository. These physical quantities, derived from vector HMI SDO data, provide various characteristics of ARs, such as the gradient of the field, magnetic flux, shear angle, or current density. The ^{3}He/^{4}He ratio shows the strongest correlation with the absolute value of the net current helicity (a measure of twist in the vertical field) and ^{3}He intensity with the fractional area with shear $>$ 45 degrees (a measure of the extent of extreme magnetic shear). We discuss the implications of these results for ion acceleration in impulsive flares.

August 7, 13:30-15:00 - Afternoon Oral Session S 390-5

How open data and interdisciplinary collaboration improve our understanding of space weather: A risk and resiliency perspective

Vincent Ledvina [1,2,3], Erika Palmerio [4], Ryan McGranaghan [5,6], Alexa Halford[7], Aidan Thayer[8], Laura Edson [3,7], Elizabeth MacDonald [3,7], Don Hampton[1]

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Space weather refers to conditions around a star, like our Sun, and its interplanetary space that may affect space- and ground-based assets as well as human life. Space weather can manifest as many different phenomena, often simultaneously, and can create complex and sometimes dangerous conditions. The study of space weather is inherently trans-disciplinary, including subfields of solar, magnetospheric, ionospheric, and atmospheric research communities, but benefiting from collaborations with policymakers, industry, astrophysics, software engineering, and many more. Effective communication is required between scientists, the end-user community, and government organizations to ensure that we are prepared for any adverse space weather effects. With the rapid growth of the field in recent years, the current Solar Cycle 25 maximum, and the evolution of research-ready technologies, we believe that space weather deserves a reexamination in terms of a risk and resiliency framework. By utilizing open data science, cross-disciplinary collaborations, information systems, and citizen science, we can forge stronger partnerships between science, industry, and the public and improve our readiness as a society to mitigate space weather impacts. The objective of this talk is to raise awareness of these concepts as the solar maximum peaks, coinciding with an increasingly technology-dependent society, and introduce a unique way of approaching space weather through the lens of a risk and resiliency framework that can be used to further assess areas of improvement in the field.

August 7, 15:00-15:30 - Afternoon Poster Session S 390-4

Geomagnetic Storms due to solar activity during the Rising Phase of Solar Cycle 25

Gebregiorgis Abraha Fikade [1], Yikdem Mengesha Gebrehiwot [1], Solomon Belay Tessema[2]

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A geomagnetic storm is a major disturbance of Earth's magnetosphere that occurs when there exists an exchange of energy from the solar wind into the space environment surrounding Earth. The largest storms that result from these conditions are associated with coronal mass ejections (CMEs) with magnetic field embedded in it arrives at Earth magnetosphere. Solar cycle 25 was begin in 2019 and geomagnetic storm occurred almost every month since the beginning of the cycle. This study examines the occurrences rate of geomagnetic storms during the rising phase of solar cycles 25. It also investigates the solar sources of the storm, is it CME or CIR. The Disturbed storm time (Dst), Sunspot Number (SSN), and Solar wind Speed (SW) data were used in the study. The study establishes that the magnitude of the rate of occurrences of geomagnetic storms increase. At the beginning of the phase 2019 and 2020 only weak storms were observed. Except the sever storm of November 14/2021, in the years 2020 and 2021 the storms are rated as comparable moderate and weak storms, As the solar cycle is nearing to its peak the year 2023 was observed as the most disturbed year so far with moderate and intense geomagnetic storms (Dst $<$ -100 nT) occured and are mostly associated with coronal mass ejections (CMEs).

August 7, 15:00-15:30 - Afternoon Poster Session S 390-4

On the distribution of Forbush decreases and their size classification

Innocent Eya

University of Nigeria.

A Forbush decrease (Fd) is a temporary reduction in the cosmic rays (CR) flux observed on Earth. However, there has been a debate on how to classify Fds based on their sizes, mainly due to the incompleteness in the distribution of Fd sizes occasioned by the scanty/unavailability of Fds of magnitudes less than 0.3%. The manual measuring of Fd from raw CR data made it difficult to identify numerous Fds of size $< 0.3\%$. However, with recent advancements in algorithms, Fds of size up to 0.01% can be identified from any CR data, thereby uncovering the numerous Fds of far less than 0.3%. In this analysis, we utilized an automated Fd measurement algorithm on CR data from nine Neutron monitors covering the period from January 1999 to December 2006 to uncover the Fds in them. We found that the size distribution of Fds is uni-modal and objectively complete. The probability of having Fd in the second quarter-sides of the lower end and larger end of the size distribution is less than 5% at a 95% confidence level. Having more Fds is not likely to shift the peak of the distribution significantly. Based on this, we can confidently classify Fds based on their sizes. Fds of size $\geq 2\%$ are considered large Fds, while those $< 2\%$ are small Fds. The distribution of the Fd size is best described by a power law, just like other natural phenomena. Moreover, we also analyzed the interplay of large and small Fds with solar activity parameters.

August 7, 15:00-15:30 - Afternoon Poster Session S 390-4

On the influence of solar-geomagnetic properties on small-magnitude, algorithm-selected Forbush decrease

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The precise computation of the magnitude and time of sudden reductions in galactic cosmic ray (GCR) intensity has remained an important stage in studying Sun-Earth-related phenomena. This paper discusses the analysis of daily-averaged cosmic ray (CR) data from three known Neutron Monitor stations located at altitudes above 1000 m, namely, CALG, CLMX and ESOI spanning from 1999 2006 using an algorithm-selected technique. We compare the catalogs of small-magnitude FDs as recorded by the three stations to demonstrate how GCRs respond to the passage of these properties. Our technique selected 202, 54 and 95 FD events with a magnitude less than 3% respectively from CALG, CLMX and ESOI. Also, 30 of the FD events were detected simultaneously in the standard time by the three monitor stations irrespective of their altitudes and cut-off rigidity. For the 30 simultaneous FDs, the average values of the events are found to be -8.40, -6.60 and -7.40 for stations CALG, CLMX and ESOI respectively. A statistical t-test and the non-parametric, two-dimensional KolmogorovSmirnov (K-S) tests of the FD data show that 5 80% of the observed variability in GCR flux intensity at the same time of FD could be attributed to solar-geomagnetic effects. We discuss these results in the context of FD events and their dependence on solar-geomagnetic properties.

August 7, 15:00-15:30 - Afternoon Poster Session S 390-4

Rieger Periodicity Variation in Solar Mg II Spectral Emission During Various Cycles

Pieter Kotze

Centre for Space Research, North-West University, Potchefstroom

The temporal variation of the approximately 155-day Rieger solar periodicity is investigated in the Mg II spectral emission as observed at 280 nm during the interval between 1980 and 2019. Daily mean values of Mg II at each annual interval are spectrally analysed using LombScargle and Morlet wavelet techniques to obtain the temporal behaviour of particularly the 155-day Rieger as well as the 27-day solar rotation periodicities. Results obtained indicate substantial power in the Rieger periodicity that varies on an annual basis. In particular, the power of the Rieger periodicity exceeds that of the 27-day period during the maxima of Solar Cycles 21 (1981), 22 (1992), and 23 (2001), with the power of the 27-day periodicity dominating during the minima of these cycles. In contrast to these findings, we observe a substantial increase in power of the Rieger periodicity in comparison to that of the 27-day solar rotation period during the minima of Cycles 23 (2006, 2007) and 24 (2018, 2019).

During this time the solar magnetic field experienced a substantial diminishing in the strength of several spherical harmonics with extremely low solar activity during the minima of Cycles 23-24 and 24-25. Recent studies showed that the Rieger periodicity is related to the instability of magnetic Rossby waves due to the solar differential rotation and magnetic field in the dynamo layer. A possible explanation for Rieger periodicity behaviour is the peculiar characteristics of the solar magnetic field during Cycles 23 and 24 and the resulting Rossby waves.

August 7, 15:00-15:30 - Afternoon Poster Session S 390-4

What is the Effect of Solar Wind Disturbances on Small-Amplitude Simultaneous Forbush Events During Solar Cycle 23?

Jibrin Alhassan [1], Ogbonnaya Okike [2], Augustine Chukwude [1], Finbar Odo [1], Innocent Eya [3], Jude Ugwu [3], Evaristus Iyida [1], Romanus Ugwoke [4], Firew Menteso [1,5], Dominic Obiegbuna [3], Orji Orji[1]

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The transient and rapid reduction in cosmic-ray (CR) flux intensity commonly referred to as Forbush decrease (FD), is widely used as a mediator variable in searching for solar-terrestrial weather linkages. Whereas, a wide range of solar-terrestrial literature is replete with high-magnitude (amplitude 3%) FD-based analyses, the empirical connections between low amplitude (FD(%) 3) events and Sun-Earth variables are seldomly tested. It is recently observed that the shortage of such studies might be due to the daunting task of accurate detection/precise timing of FDs and other transient astrophysical events. Using a highly sensitive version of the FD detection algorithm, we selected 264, 267, and 206 low amplitude (FD(%) 3) FDs from the daily CR data of Hermanus (HRMS), Newark (NWRK) and Oulu (OULU) neutron monitor (NM) stations respectively, during solar cycle 23. A total of 80 simultaneous small-amplitude FDs were identified from the three stations with the aid of a simple coincident computer code. We find statistically significant correlations at a 95% confidence level between the planetary K-index (kp), disturbance storm time index (Dst), planetary A-index (ap), and the corresponding simultaneous weak FDs at each of the stations.

SEARCH FOR PHASE OF GALACTIC COSMIC RAY VARIATIONS IN THE 21-25 SOLAR CYCLES

Alexei Struminsky [1], Anatoly Belov [2], Raisa Guschina [2], Victor Yanke [2], Irina Grigorieva3

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Traditionally, the sunspot minimum is associated with beginning of galactic cosmic rays (GCRs) modulation in the 11-year cycle.However, the beginning of a new sunspot cycle does not reflect all physical processes on the Sun that modulate GCRs in the heliosphere.To clarify the beginning of the GCR modulation cycle, we look for an unknown variation phase choosing other options of zero time. We compare the amplitude of zero harmonic GC?R variations, calculated for 5, 10 and 20 GV rigidities in the 21 - 25 solar cycles, for 11 years after: (1) the last proton event of the previous cycle;(2) the maximum of polar solar magnetic field Bpole and (3) the maximum of GCR intensity. Choosing zero (3), the reversal of Bpole polarity practically coincides in time for the 21-25 cycles.To the right of the polarity reversal GCR variations are similar in pairs of cycles: (21, 23) Bpole <0 and (22, 24) Bpole >0, and there is no such similarity to the left. Apparently, GCR fill the heliospherebythe drift mechanism to the right and GCR are removed from the helospere by the convection "to the left". The role of low coronal holes (LCHs) and coronal mass ejections CME is important "to the left". The amplitude of GCR variations is almost the same in the 21st, 23rd and 24th cycles, but itminimum in the 25th cycle (slow CMEs and small area of LCHs) and maximum in the 22nd cycle (powerful flares and CMEs of 1989 and 1991years).

August 7, 15:00-15:30 - Afternoon Poster Session S 390-4

Terrestrial Response to Solar Events; Investigation of Solar wind parameters during Solar Flare Occurrence in Solar Cycle 25

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A study of terrestrial response to solar events of solar cycle (SC) 25 was made. This work is to analyze the response of solar wind parameters to solar flares (SFs). Furthermore, we seek to investigate the relationship between SFs and Geomagnetic storms (GMs) by studying the behavior of the Earths magnetosphere approximately five days before and after the occurrence of each solar flares of SC 25 using the Dst index to observe the magnetospheric disturbance. The solar flare data was obtained from solarham.com while the solar wind parameters were obtained from NASA OMNI website from May 7, 2021 to October 3rd, 2022. Our findings have revealed that even a weak X class flare can produce a weak/moderate GMs as long as it is geoeffective.

August 7, 15:00-15:30 - Afternoon Poster Session S 390-4

High Precision, High Time-Cadence Measurements of the MgII Index of Solar Activity by the Extreme Ultraviolet Sensor Aboard the NOAA GOES-R Series

Martin Snow [1,2], William McClintock[2]

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One of the instruments on the Geostationary Operational Environmental Satellites is the Extreme and Ultraviolet Sensor (EUVS). Channel C of EUVS measures the Magnesium II core-to-wing ratio with high signal-to-noise ratio at a cadence of three seconds. This presentation will describe the design of the instrument and give an overview of the data collected so far. Available data products range from the full-cadence operational data measured every three seconds to science-quality daily averages.

The instrument measures the spectrum of the Sun from 275 to 285 nm with a spectral resolution of 0.1 nm. It uses a diode array with a sampling width of 0.02 nm, providing five samples per slit width.

The first of these instruments became operational in January 2017 and continues through the present.

Comparative Researches of Two Distinct Cosmic Ray Events(Forbush decrease and GLE event) Caused by the Solar Eruptions during September, 2017

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Two large solar eruptions on AR 12673 produced a Forbush decrease (FD) on September 8 and ground-level enhancement (GLE) eventon September 10, 2017. The two contrast cosmic ray (CR) events occurring within two days, associated with two similar X-class solar flares (X9.3 and X8.2) and sharing the same activeregion on the Sun, provide usa rare opportunity to understand the dominant factors that determine the characteristicsof transient CR events. Usinga suite of modern-dayinstruments, using ground-based CR detectors, we continuously tracked solar eruptions from the Sun to theEarth, revealing the complete causeeffect chain of these two events. We conclude that different consequences on the ground arise from two effects of the eruptions near the Sun:(1) the geometric effect of CMEs and (2) the intensity effect of CME-driven shocks. The rst eruption, which originated at the heliographic longitude of W34 on September 6, had its CME ejecta and CME-driven shock intercept the Earth, leading to the FD event. The second eruption, which occurred on September 10 at W88^o, only had its far ank reach the Earth. The peak shock speed of 3344 km s^{-1} of the second eruption, much faster than 2175 km s^{-1} of the rst eruption, is the dominant factor producing GLE event, even though the rst eruption is better connected magnetically to the Earth and has a similar are. The results indicate the production of GLE particles can be dominated by fast-enough CME-driven shocks. In addition, the Neupert effect was shownusing HXR data fromInsightand SXR data from GOES satellite.

August 7, 15:00-15:30 - Afternoon Poster Session S 390-4

Longitudinal variation of ionospheric electrondensity over 10 years provided by Swarm satellites.

Amal Loutfi [1], Aziza Bounhir [2], Frederic Pitout [3], Zouhair Benkhaldoun[1]

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The electron density in the topside ionosphere, monitored by Langmuir probes on Swarm satellites, has been systematically analyzed to investigate the Equatorial Ionization Anomaly (EIA) over a decade (2013-2023). This analysis provides valuable insights into the behavior of ionospheric density during both quiet and disturbed days, as well as its variations with the solar cycle, and seasonal changes across different longitudes, latitudes, and local time sectors. Moreover, the study sheds light on the interhemispheric asymmetry of the Equatorial Ionization Anomaly in the African sector, offering a comprehensive understanding of this phenomenon in the region. Additionally, the latitudinal distribution of total magnetic field intensity at mid- and low-latitude regions in various longitudinal and local time sectors has been quantified, enhancing our knowledge of magnetic field variations in these regions.

August 7, 15:30-17:00 - Afternoon Oral Session S 390-6

The radiation effort at SANSA Space Weather center and as an ICAO-designated regional warning center

Nondumiso Khumalo, Rendani Nndanganeni

South African National Space Agency (SANSA), Hermanus, SA

The South African National Space Agency (SANSA) has operated the Regional Warning Center (RWC) for Space Weather (SWx) in Africa since 2010. In 2018, South Africa, through SANSA, was designated by the International Civil Aviation Organisation (ICAO) as a Regional Centre for the provision of space weather information to international air navigation. SANSA is in a position to work together with all the affected sectors, and government, to make provision for space weather capability that addresses both national and regional requirements and mitigation measures against space weather risks.

Over the past 14 years, SANSA has developed the capability to monitor and forecast space weather as well as prioritize research projects that enhance the modeling ability of the center. Space weather can disrupt these technological systems, and infrastructure, including but not limited to satellite and airline operations, communications networks, navigation systems, oil and gas pipelines, and the electric power grid.

This presentation will discuss the effort that SANSA has made in terms of studying radiation exposure at aviation altitude and the ICAO regional status.

August 8, 08:30-10:00 - Plenary Talk S 390

Beyond Flatland: A Star of Many Dimensions

Sarah Gibson

NCAR/HAO

The more we learn about the Sun, the more we can appreciate its essential complexity. Multi-wavelength observations reveal its structured coronal atmosphere, and ever-higher temporal and spatial resolutions expose its spectacular dynamics. Helioseismology penetrates its depths, and spacecraft views from off the Sun-Earth line yield the beginnings of a three-dimensional perspective. Underlying this complexity is solar magnetism the consequence of a cycling dynamo and the cause of solar eruptions that originate in stressed and twisted magnetic fields. In this talk, I will highlight critical areas of solar physics, presenting recent advances and open questions associated with the generation, storage and release of magnetic energy and resulting space weather at the Earth. I will then look to the future, considering how sustained observations from the Suns poles and from a truly global view on solar and heliospheric magnetic fields could change the paradigm of Sun-Earth investigations.

Analysis of coronal holes and their impact on space weather based on FengYun-3E X-EUVI data

Qiao Song [1,2,3,4], Xinhua Zhao [2], Shuhong Yang [5], Jing-Song Wang [1,3,4]

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Coronal holes are open magnetic field structures commonly found in the solar corona and are generally considered to be the main source of high-speed solar wind. High speed streams from coronal holes, especially low-latitude coronal holes, may cause geomagnetic storms and are therefore important objects for the space weather research. The Solar X-ray and Extreme Ultraviolet Imager (X-EUVI) onboard the FengYun-3E satellite is China's first in-orbit solar imaging instrument, which can conduct high-cadence and full-disk imaging observations in the extreme ultraviolet (EUV) 195 channel of the Sun. By using the X-EUVI images and the corresponding automatic identification method, we analyze the low-latitude coronal holes, including their position and morphology changes over time, and combined with their geomagnetic influences, to study the relationship between the observational characteristics of coronal holes in EUV images and the geo-effectiveness. The results show that the X-EUVI EUV data can accurately reveal the coronal hole boundary, and also observe the smaller-scale features such as bright points in the coronal holes, which provides strong support for the study of overall planetary geomagnetic response of the coronal hole.

August 7, 15:30-17:00 - Afternoon Oral Session S 390-6

Space Weather Effects on the Ionosphere of Earth

Tshimangadzo Matamba, Donald Danskin

South African National Space Agency (SANSA)

During severe solar storms, the space weather conditions cause variation in the ionosphere of Earth. The total electron content (TEC) varies due to the changes of the driving forces of the solar wind during the storm. The South African National Space Agency (SANSA) near-real-time global navigation satellite system products are used to monitor the variation in TEC over Southern Africa. Depending on the phase of the geomagnetic storm, the variation of TEC is observed from the maps of TEC. The TEC is also compared with estimates from ionosondes and the quiet-time AFriTEC model.

August 7, 15:30-17:00 - Afternoon Oral Session S 390-6

Space weather impact of three solar flares observed by the POEMAS telescope at 45 and 90 GHz

Adriana Valio, Karla Lopez Araujo, Ruben M. Romero Ramirez, Jose Luis Gamonal Valenzuela, Douglas F. da Silva

Center for Radio Astronomy and Astrophysics Mackenzie, Mackenzie Presbyterian University, São Paulo, Brazil

Solar flares are often associated with coronal mass ejections (CMEs), which when directed towards Earth, may impact the magnetosphere, causing geomagnetic storms and altering space weather conditions. This study investigates three solar flares observed by the POEMAS radio telescope (45 and 90 GHz) in 2012 to discern flare/CME characteristics influencing Earth's space weather. Flares on March 2nd and June 6th (GOES class M) were followed by partial CMEs, while the July 12th event (X1.4) featured a more energetic halo CME. Detailed analysis, utilizing GOES 15 X-ray data, RSTN-POEMAS radio observations, and gyrosynchrotron fitting of radio spectra, revealed complex dynamics. The accelerated electron distribution exhibited a hard spectral index of 2.0 for all three flares. Ratios of CME kinetic energy to soft X-ray energy were approximately 40, 50, and 10 for March 2nd, June 6th, and July 12th events, respectively, underscoring the distinct nature of solar flares and CMEs. Geomagnetic storm potential was assessed using Dst and Kp indices. Despite being fast and energetic, the March 2nd CME showed no detected storm at Earth's estimated arrival, possibly due to its partial halo nature and unique active region location. The CME on June 6th may have induced a mild storm about 3.5 days later, while the largest event (July 12th) led to a moderated geomagnetic storm less than two days later. This underscores the intricate nature of solar-terrestrial interactions. The study emphasizes the importance of research to refine our understanding of the dynamic interplay between solar activity and Earth's space environment.

August 7, 15:30-17:00 - Afternoon Oral Session S 390-6

Geo-effectiveness of CME-CME Interaction events: An ensemble study using SWASTi framework

Bhargav Vaidya [1,2], Prateek Mayank [1], Stefan Lotz[3]

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The geo-effectiveness of coronal mass ejections (CMEs) is a critical area of study in the field of space weather, particularly regarding the lesser-explored domain of CME-CME interactions and their geomagnetic consequences. This study leverages the SWASTi framework to simulate a range of CME-CME interaction scenarios within realistic solar wind conditions.

The study concentrates on the dynamics of the magnetic flux, velocity, and density of CMEs, and their combined and individual impacts on the geomagnetic storm index (Dst). We observe that increases in the initial density and velocity of CMEs generally lead to heightened geomagnetic activity. Interestingly, the impact of magnetic flux at eruption on storm severity depends on the chirality of the interacting CMEs. This suggests that magnetic reconnection and flux cancellation can mitigate storm intensity. Our findings underscore the significance of the relative tilt of interacting CMEs and reveal that variations in CME properties across different longitudes can drastically affect geomagnetic storm intensity. Furthermore, we show that inhomogeneous ambient solar wind conditions significantly alters the nature of CME-CME interaction, and hence its geo-effectiveness.

August 8, 10:00-10:30 - Morning Poster Session S 390-5

Exploring the Impact of Space Weather Elements on Telemetry Metrics in Low Earth Orbit for Small Satellites

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This research delves into the intricate relationship between space weather phenomena and the telemetry parameters of small satellites operating in the Low Earth Orbit (LEO). As small spacecraft become increasingly vital for various scientific, commercial, and communication purposes, understanding the influence of space weather factors on their telemetry metrics becomes crucial. This study employs comprehensive data analysis and modeling techniques to investigate the impact of solar radiation, geomagnetic storms, and other space weather elements on the performance and reliability of small satellites in LEO. By examining telemetry data from a diverse set of small spacecrafts, this research aims to identify patterns, correlations, and potential vulnerabilities, providing valuable insights for enhancing the resilience and operational efficiency of small satellites in the dynamic space environment. The findings contribute to the broader understanding of space weather effects on satellite technology and inform strategies for optimizing small satellite missions in LEO.

August 8, 10:00-10:30 - Morning Poster Session S 390-5

Astrophysical analysis of coronal mass ejections and cosmic rays during intense geomagnetic storms

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One of the most important layers of Earth's atmosphere, the magnetosphere, is essential for absorbing charged particles such as cosmic rays and coronal mass ejections (CMEs). The goal of this study is to comprehend the astrophysical causes and phenomena of CMEs, with a particular emphasis on their appearance during strong geomagnetic storms. The study highlights the astrophysical relevance of CMEs by identifying patterns and trends connected to them through a meticulous extraction and analysis of data from the OMNI Web. Compared with the solar cycle's majority of mild CMEs, a notable subset in 2022 and 2023 showed significant consequences, providing important information about the astrophysical dynamics of these events in the context of strong geomagnetic storms.

August 8, 10:00-10:30 - Morning Poster Session S 390-5

Applied Machine Learning methods for the synthesis and inversions of the Stokes parameters in the solar context

Juan Esteban Agudelo Ortiz [1], Germain Nicols Morales Suarez [1], Santiago Vargas Domnguez [1], Sergiy Shelyag[2]

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The upcoming spectropolarimetric instruments such as DKIST, the development of new and more precise methods of magnetohydrodynamics (MHD) and the development of new numerical methods for solving the equations of radiative transfer, come both with more computational demands in power and time and with the generation of tons of data to be treated for future scientific investigation. The combination of this requirements come with the possible delaying of current going scientific investigations in terms of years. This difficulties call for the development of faster methods to treat this data. The rise of Artificial intelligence and, specifically, Machine Learning, has come with new methods to treat faster and efficiently large quantities of data in different study fields. There has been studies applied to the area of physics and astrophysics that has been trying to replicate what is done with numerical methods but using machine learning techniques, allowing processes to deminish processing time in orders of magnitude. Following this steps, and parting from previous works made on the area of synthesis and inversions using machine learning techniques applied on the sun, we aim to use data obtained from simulations such as MURaM and the associated results from applied radiative transfer codes such as NICOLE, to train Machine Learning arquitectures forward (synthesis) and backward (inversions) to study the aplication of this models on new simulation codes and observational data to be obtained in the future, contributing to the new paradigm of treating physical data with the use of artificial intelligence.

August 8, 10:00-10:30 - Morning Poster Session S 390-5

GHOTI: The GOES-R High-cadence Operational Total Irradiance project; using the EXIS SPS as a TSI proxy.

Steven Penton [1,2], Martin Snow [3], Stphane Bland [1,2], Odele Coddington [1,2], Don Woodraska [1,2]

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The GOES-R series of geostationary satellites include a redesigned instrument for solar spectral irradiance: the Extreme ultraviolet and X-ray Irradiance Sensor (EXIS). Our team uses the Sun Position Sensor (a set of high-cadence broadband visible light diodes) on GOES-16 and GOES-18 EXIS instruments to construct a high-cadence proxy for Total Solar Irradiance (TSI).

This has two advantages over the existing TSI measurements:

1) the measurements are taken at 4 Hz, so the cadence of our TSI proxy is much faster than existing measurements, such as the 6 to 24-hour measurements produced by SORCE or TSIS-1, and

2) from a geostationary position, the time series of measurements is virtually uninterrupted.

Our calibration of the GOES-R EXIS diode measurements includes thermal and sun-satellite distance corrections, while the irradiance calibration relies on TSIS-1 TIM TSI composites. Another measurement from GOES-EXIS that will be used is the Magnesium II core-to-wing ratio. The MgII index is a proxy for chromospheric activity and is measured by EXIS every 3 seconds.The combination of the two proxies is used to generate a model of the full solar spectrum similar to the NRLSSI2 empirical model.

We are in the final year of a four-year grant to develop the TSI proxy and the SSI model.

Assessing Ionospheric Responses to Geomagnetic Storms with VLBI and VGOS

Arno Rüegg, Benedikt Soja

ETH Zurich

Space weather impacts Earth's atmosphere, and accurate ionospheric models helps us study these effects. Traditionally, these models primarily use GNSS data, benefiting from its continuous, extensive global coverage. Very Long Baseline Interferometry (VLBI) provides an alternative method to measure the ionosphere's Vertical Total Electron Content (VTEC), which allows the potential utilization of VLBI observations to enhance ionospheric models, provided that the robustness and reliability of the derived values are sufficient. The launch of the VLBI Global Observing System (VGOS) and its four frequency band observations significantly enhances our ability to accurately measure VTEC.

Our research utilizes a new approach based on least squares adjustment designed for VTEC estimation from both legacy VLBI and VGOS data. We analyze operational 24-hour sessions, focusing on sessions at co-located stations where VLBI and VGOS data overlap, allowing for unique comparative studies. The VTEC values obtained through our method are examined for their consistency and accuracy. For validation, we compare our results with two independent GNSS-based datasets, namely Global Ionosphere Maps (GIM) and Madrigal TEC Maps (MTM). Initial comparisons show that VGOS sessions correlate better with GIM than VLBI sessions, indicating a higher consistency overall.

Furthermore, our algorithm supports the creation of long-term ionospheric time series, enabling the study of variations in relation to solar activity. Besides the long-term evaluations, also the short-term effects of space weather on the ionosphere will be analyzed and evaluated. Concretely, we will study the ionospheric response during geomagnetic storms using legacy VLBI and VGOS data.

SolarKAT: Imaging Pipeline for Solar Interference Mitigation in MeerKAT

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In radio astronomy, one of the biggest challenges is radio frequency interference (RFI) caused by different sources, whether artificial or natural. This study focuses on mitigating interference from a natural source, the Sun, which can completely corrupt the data. To address this issue, we developed SolarKAT, an imaging pipeline that effectively mitigates interference caused by the Sun in MeerKAT, recovering the viabilities rather than discarding them. This is achieved while preserving the flux measurements in the main field. SolarKAT is versatile and can be applied to general radio astronomy observations and solar radio astronomy; additionally, generated solar images can be used for weather forecasting. SolarKAT is deployed in Stimela. It is based on existing radio astronomy software, including CASA, breizorro, WSclean, Quartical, and Astropy.

August 8, 10:00-10:30 - Morning Poster Session S 390-5

Simulating the Magnetospheric and Geomagnetic Impact of Coronal Mass Ejections

Dibyendu Nandi, Souvik Roy

Indian Institute of Science Education and Research Kolkata

One of the striking manifestations of space weather are geomagnetic storms which occur when magnetic transients such as coronal mass ejections (CMES) impact the Earths magnetosphere. Predicting the impact of a CME remains an outstanding challenge because in-situ observations near-Earth only provide a small time window and complex computational models are prohibitively time-intensive. We have developed a relatively simpler and time-efficient magnetohydrodynamic model named STORMI for exploring solar storm magnetospheric interaction. Based on fundamental physics and some idealizations, we demonstrate that the STORMI model simulated geomagnetic storm intensity index compares favourably with observations.

Observing space weather events with the autonomous ASKAP radio telescope

Vanessa Moss, Aidan Hotan, Emil Lenc, Zoe Taylor, Rajan Chhetri, John Morgan, Keith Bannister, Mark Cheung, Ron Ekers

CSIRO

We present an overview of the work done to date in enabling space weather related observations to be carried out at radio wavelengths with ASKAP. The ASKAP radio telescope is an array of 36 x 12m antennas located at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory in Western Australia, and is equipped with innovative phased-array-field receivers which greatly increase its field of view in comparison with single-pixel feeds. ASKAP is primarily a survey instrument carrying out a number of all-sky surveys, but has a modest amount of time available for novel and high-impact guest science.

Over the last year, this guest science has expanded to include technical demonstration of ASKAPs ability to conduct interplanetary scintillation (IPS) observations of the solar heliosphere, making use of its instrumental capabilities, its autonomous operations model and the new CRACO backend currently under commissioning for high time resolution observations on the order of milliseconds. We are currently in the process of broadening this work to be a more regular and sustainable part of ASKAP science operations, and keen to explore the possibilities for future collaborations and coordination with the broader space weather community.

In this talk, Ill introduce ASKAP, its current capabilities and autonomous operations (and implications for its ability to be responsive to time-critical events), and showcase a number of space weather related observations that ASKAP has conducted as part of its transition from commissioning to full-survey operations.

August 8, 10:00-10:30 - Morning Poster Session S 390-5

Precise Point Positioning Accuracy of LAUTECH: A Seamless Opportunity for GNSS Applications in Nigeria.

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This manuscript presents the result of the precise point positioning accuracy of LAUTECH for seamless GNSS applications in Lautech, Nigeria. A dual-frequency ublox GNSS receiver module with a ublox antenna was setup in an open-sky environment at the LAUTECH GNSS laboratory (8° 10' 13.92080", 4° 16' 8.07241", 403.411 m) to log GPS and GLONASS satellite observation data at 1 Hz for 24 hours. The data obtained was converted to a RINEX observation format using appropriate software. Online PPP was done through the Natural Resources of Canada (NRCan) service using rapid and final IGS products. The result shows that less than 11mm horizontal and less than 36mm vertical coordinates in GPS+GLONASS hybrid mode of operation with 95% confidence level is realizable in LAUTECH with the low-cost ublox ZED F9P compact module. It was witnessed that the combination of constellations enhanced the PPP accuracy when compared to the results of GPS-only and GLONASS-only modes of operation. The results will be useful for PPP solutions for GNSS seamless applications in LAUTECH, Nigeria.

August 8, 10:00-10:30 - Morning Poster Session S 390-5

Upstream solar wind prediction up to Mars by an operational solar wind prediction systems

Jingjing Wang

National Space Science Center, Chinese Academy of Sciences

Combining the upstream solar wind observations measured by Mars Atmosphere and Volatile Evolution (MAVEN), Advanced Composition Explorer(ACE) and Deep Space Climate Observatory (DSCOVR) from October 2014 to April 2021, we investigate the statistical properties of the background solar wind at Mars and Earth. By applying an operational solar wind prediction system (Wang et al., 2018, doi.org/10.1051/swsc/2018025) in Space Weather Prediction Center (SEPC), we simulate the solar wind conditions and carry out a comparative analysis with observations to study our model performance. We find that our model is able to simulate the solar wind conditions upstream of Earth and Mars, corresponding to the different heliocentric distances and different levels of solar activity. Furthermore, we apply an event?based evaluation by analyzing the high speed enhancements (HSEs), and find that the hit rate of HSEs is 70.38% and 66.37% for Earth and Mars, respectively. By predicting the HSEs at Earth (Mars), our model reaches a Mean Absolute Error (MAE) of 83.93 km/s (65.91 km/s) and 22.98 hr (21.65 hr) for maximum speed and arrival time prediction error, respectively. We also conduct a three-month case study, from November 2020 to January 2021, analyzing solar wind conditions upstream of Earth, Mars, and measured by Tianwen-1 (China's first Mars mission), for which our model is capable to predict the upstream solar wind conditions up to Mars.

August 8, 10:00-10:30 - Morning Poster Session S 390-5

The first multi-year analysis of TEC results obtained at Oukaimeden Observatory. Study of the solar and geomagnetic activities on TEC behaviour

Marouane El Bahraoui[1], Mohamed Kaab[1,2], Zouhair Benkhaldoun[1], Noura Azebabad[1]

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One of the main parameters that characterize the ionosphere is the electron density showing changes with respect of solar activity, geomagnetic activity, position, season, ...etc. The quality of radio signals passing through this mysterious area of our Earths atmosphere is affected by the behavior and state of the electron density. Hence the need to understand its evolution as a function not only of time but also of solar and geomagnetic activity. One of the key parameters making it possible to identify this behavior and its connection with the degradation of radio signals used in radio telecommunications is the measurement of the total electron content (TEC). Variations in TEC can cause signal delays, phase distortions, and scintillations, impacting the accuracy and reliability of telecommunications systems. The aim of this study is to represent the first multi-year analysis of TEC results obtained from GPS station installed at the Oukaimden Observatory, located at an altitude of about 2700 meters on the High Atlas mountain range, about 78 kilometers south of Marrakech, Morocco. We are going to present the evolution of total electron content (TEC) with respect to solar and geomagnetic parameters: in this context, F10.7 solar flux and Interplanetary Magnetic Fields (IMF) as solar proxies and Kp and Dst indices as geomagnetic activity proxies are considered

Investigation of Solar and geomagnetic activities on thermospheric neutral temperature and neutral winds over Oukaimeden Observatory.

Noura Azebabad [1], Mohamed Kaab [2], Zouhair Benkhaldoun[3]

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Thermospheric winds and neutral temperature are two key parameters for a good understanding of the behavior and dynamics of the ionosphere at altitudes of around 200 km. In this work we present the first multi-year results of our analysis of the effects of solar and geomagnetic activities on thermospheric neutral temperature and neutral winds over Oukaimeden Observatory. These results are obtained by measuring the Doppler shift and the Doppler Broadening via an imaging Fabry Perot Interferometer which provide measurements of the 630.0nm emissions caused by dissociative recombination of the O2+. Our analysis obtained during the period from January 2014 to January 2017 including observations from 966 nights, focuses on the evolution of these two thermospheric parameters as a function of two indices: the first ,namely F10.7cm, is used to caracterize the solar activity and the second , Kp index, is used to decribe the geomagnetic activity. A preliminary analysis conducted with the first set of data shows that the neutral temperature is strongly linked to solar activity during the solar cycle while neutral winds are much more linked to seasonal variation, rather than to the solar cycle.

August 8, 10:30-12:00 - Morning Oral Session S 390-7

2,000 years of twinkling: lessons learned from a brief history of astronomical scintillation

Emily Kerrison [1,2], Ron Ekers [2], Vanessa Moss [2], [1], John Morgan [3,2], Rajan Chhetri [3,2]

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Some time around 350BCE, the Greek philosopher Aristotle wrote about the fixed stars which twinkle and the planets which do not. This is perhaps the earliest reference to the scintillation of compact astronomical objects, a phenomenon which is used today by many branches of astronomy, from the study of fast radio bursts to the tracking of space weather. But the path from this ancient remark to modern scientific applications is a twisted one full of challenged assumptions and (mis)communication. In this talk I shall discuss how the physics behind the scintillation of radio sources, first ionospheric, then interplanetary and interstellar, was gradually understood over the course of many years, with a focus on the angular size dependence of this phenomenon. As with the twinkling of stars noticed by the Greeks, this radio frequency scintillation was initially misinterpreted as an intrinsic effect where in fact we now know it is related to aspects of wave propagation through a turbulent medium which are not so intuitive, but once this is understood we have a powerful tool to probe the space weather environment without even having to go there.

August 8, 10:30-12:00 - Morning Oral Session S 390-7

A Detailed Sun-to-Earth Investigation of the Space Weather Conditions that Trigerred the Loss of the Starlink Satellites in February 2022

Yoshita Baruah [1,2], Souvik Roy [2], Suvadip Sinha [2], Erika Palmerio [3], Sanchita Pal [4], Denny Oliveira [5,6], Dibyendu Nandi [1,2]

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Coronal mass ejections (CMEs) and high-speed streams (HSSs) directed towards Earth are significant drivers of space weather. Upon reaching Earth fast CMEs and HSSs, characterized by strong southward-directed magnetic fields with respect to Earth's magnetic field, interact with the magnetosphere, triggering geomagnetic storms. These events deposit a considerable amount of energy into the magnetospheric system, primarily through Joule heating, causing the thermosphere to expand upwards. This expansion leads to increased density at Low Earth Orbit (LEO) altitudes, resulting in heightened atmospheric drag on satellites and affecting their orbital lifetime. In February 2022, 38 out of 49 Starlink satellites launched by SpaceX re-entered the atmosphere due to such a geomagnetic storm. Our study delves into the solar events preceding this incident, analyzing solar wind data from L1 to identify interplanetary structures near Earth associated with the geomagnetic storms. Through data-driven magnetohydrodynamic simulations, we examine the impact of CMEs on Earth's magnetosphere and assess their effect on the orbits of Starlink satellites using empirical methods and simulations, establishing a causal relationship across the Sun-Earth system. Our findings reveal that the geomagnetic storms affecting the Starlink satellites were relatively moderate in intensity. However, besides space weather and low-altitude insertion, certain physical characteristics of the satellites also contributed to their rapid de-orbiting and loss.

Forecasting Geoffective Events and Evaluating the Most Predictive Features through new Classifier-Dependent Ranking Scheme

Emma Perracchione [1], Sabrina Guastavino [2], Katsiaryna Bahamazava [1], Fabiana Camattari [2,3], Daniele Telloni [3], Michele Piana [2,3], Anna Maria Massone[2]

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This study addresses the prediction of geomagnetic disturbances by exploiting machine learning techniques. Specifically, the Long-Short Term Memory recurrent neural network, which is particularly suited for application over long time series, is employed in the analysis of in-situ measurements of solar wind plasma and magnetic field acquired over more than one solar cycle, from 2005 to 2019, at the Lagrangian point L1. The problem is approached as a binary classification aiming to predict one or more hour in advance a decrease in the SYM-H geomagnetic activity index below the threshold of -50 nT, which is generally regarded as indicative of magnetospheric perturbations. The strong class imbalance issue is tackled by using an appropriate loss function tailored to optimize appropriate skill scores in the training phase of the neural network. Beside classical skill scores, value-weighted skill scores are then employed to evaluate predictions, suitable in the study of problems, such as the one faced here, characterized by strong temporal variability. For the first time, the content of magnetic helicity and energy carried by solar transients, associated with their detection and likelihood of geo-effectiveness, were considered as input features of the network architecture. Their predictive capabilities are demonstrated through a mathematically-convergent new feature ranking algorithm which is taylored for the considered classifier, e.g. LSTM.

August 8, 10:30-12:00 - Morning Oral Session S 390-7

Machine learning techniques for solar physics and space weather

Anna Maria Massone [1], Sabrina Guastavino [1], Emma Perracchione[2]

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The study of solar flares and coronal mass ejections may offer a unique opportunity to better understand both, fundamental processes on the Sun, and their space weather impacts at Earth.This talk will describe machine learning (ML) and deep learning (DL) approaches that can be a crucial key to understanding these open science issues. More specifically,first results obtained within the two recently funded ARCAFF and AIxtreme projects will be illustrated. On the one hand, theActive Region Classification and Flare Forecasting (ARCAFF) project, funded by the European Union within the Horizon Europe Framework Programme, aims to improve flare forecasting capabilities by developing DL models and exploiting the large amount of available space-based solar observations. On the other hand, the AI for predicting extreme weather and space weather events(AIxtreme) project, funded by the Italian Fondazione Compagnia di San Paolo, aims to monitor and forecast space weather by combining deterministic models and advanced machine learning techniques in a new approach in which the physical knowledge typical of deterministic approaches, is included into the learning process typical of a learning machine.

August 8, 10:30-12:00 - Morning Oral Session S 390-7

Sun Neural Radiance Fields: From Images to 3D Reconstructions of the Solar Atmosphere

Robert Jarolim[1], Benoit Tremblay[1], Andrs Muoz-Jaramillo[2], Anna Jungbluth[3], Kyriaki-Margarita Bintsi[4], Miraflor Santos[5], James Mason[6], Angelos Vourlidas[6], Cooper Downs[7], Ron Caplan[7], Sairam Sundaresan[8]

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Over the last 15 years, at most three satellites observed the Sun in EUV at any given time. Additionally, these satellites have been tied to the ecliptic plane, thus incapable of observing the solar poles directly. However, a complete image of the 3D Sun is required to fully understand the dynamics of the Sun (from eruptive events to space weather), to forecast EUV radiation to protect our assets in space, to relate the Sun to other stars in the universe, and to generalize our knowledge of the Sun-Earth system to other host stars.

To maximize the science return of multiple viewpoints, we propose a novel approach that unifies and smoothly integrates data from multiple perspectives into a consistent 3D representation of the solar corona. We leverage Neural Radiance Fields which are neural networks that achieve state-of-the-art 3D scene representation and generate novel views from a limited number of input images. We adapted a neural radiance field for the Sun (SuNeRFs) to generate a physically-consistent representation of the 3D Sun, with the inclusion of radiative transfer and geometric ray sampling that matches the physical reality of optically thin plasma in the solar atmosphere. SuNeRFs leverage existing multi-viewpoint observations and act as virtual instruments that can fly out of the ecliptic, view the poles, and be placed anywhere in the solar system at no additional cost.

This is an example of how deep learning can be used to significantly enhance observational capabilities by creating virtual observatories.

August 8, 13:30-15:00 - Afternoon Oral Session S 390-8

Examining the Ability of Machine Learning Models to Predict SEP Events Utilizing Two Solar Cycles of Observations

Spiridon Kasapis [1], Irina Kitiashvili [1], Alexander Kosovichev [2], Viacheslav Sadykov [3], Pau Kosovich [2], Patrick O'Keefe [2], Vincent Wang[1]

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Solar Energetic Particle (SEP) events, mainly originating from magnetic reconnection processes during solar flares or swift coronal mass ejections, pose significant radiation hazards to aviation, spacecraft electronics, and particularly, manned space flights. In this study, we utilize the SHARP-SMARP dataset, which combines data from the Solar Dynamics Observatory/Helioseismic and Magnetic Imager's (SDO/HMI) Space weather HMI Active Region Patches (SHARP) with data from the Solar and Heliospheric Observatory/Michelson Doppler Imager's (SOHO/MDI) Space Weather MDI Active Region Patches (SMARP) in order to predict SEP events. We employ a variety of machine learning methods, including Support Vector Machines (SVM) and Regression Models, to evaluate the predictive power of this integrated dataset in forecasting SEP events subsequent to solar flares. Our analysis indicates that despite an increase in the amount of data compared to studies focused solely on Solar Cycle 23, the peak forecasting accuracy achieved is 0.7 ± 0.1. This is in line with, but does not exceed, previously established benchmarks. A linear SVM strategy, designed to mirror actual operational scenarios (imbalance between positive and negative examples), exhibits a slight enhancement ($+ 0.04 \pm 0.05$) in forecasting SEP events 14 hours in advance compared to earlier efforts. This finding highlights the necessity for more sophisticated models that integrate physical principles to enhance our understanding of the mechanisms driving SEP events.

Machine Learning-Based Dynamics of Interplanetary Coronal Mass Ejections Using Deterministic Models

Mattia Rossi, Sabrina Guastavino, Anna Maria Massone, Michele Piana

MIDA, Department of Mathematics, University of Genoa

Interplanetary Coronal Mass Ejections (ICMEs) are large explosions resulting from solar activity that propagate through the interplanetary medium. ICMEs directed towards the Earth, though infrequent, are particularly relevant for space weather forecast. For most of them, the dynamics of the wave front can be approximated by an analytical one-dimensional Drag-Based Model (DBM) (see, e.g., Cargill 2004, Vrsnak et al. 2010), however, for many ICME events, additional acceleration contributions (e.g., ICME-ICME interaction) may affect the dynamics, so as to render the DBM less effective.

Unlike purely data-driven Machine Learning (ML) or deterministic approaches, we propose a physics-driven ML approach similar to Guastavino et al. 2023 capable of predicting the ICME travel time: we formulate suitable extensions of the DBM to incorporate either a) in the training process by feeding neural networks with synthetic data generated by the model or b) directly in the loss function in the weight optimization process.

The Firefly (4π) Constellation: Going Above and Beyond in the Heliosphere Exploration

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Heliospheric exploration has soared to unprecedented heights in recent decades thanks to innovative space-borne missions, ground-based observatories, and advancements in computing, models, and theory. However, the progress of inner-heliospheric research is hindered by observing limitations, preventing resolving long-standing problems such as understanding the solar dynamo, solar cycle, solar wind acceleration, and the impact of active region magnetic fields on space weather and Earth. These limitations stem from observing a dynamic 3D star from a single vantage point in the ecliptic. Holistic observations, encompassing the Sun and the inner heliosphere with full 4-steradian coverage, will open new research avenues and bridge knowledge gaps in heliophysics and astrophysics. The Firefly Constellation mission concept aims to enable simultaneous observations of the Sun and inner heliosphere from multiple viewpoints, revolutionizing our understanding of the Sun's interior, solar atmosphere, and the inner heliosphere. The mission includes spacecraft strategically positioned in the ecliptic plane and at high solar latitudes, all equipped with a comprehensive payload including remote sensing and in situ instruments. We provide an overview of the Firefly mission, which is under consideration by the 2024-2033 Decadal Survey for Solar and Space Physics (Heliophysics), and its success could pave the way for groundbreaking discoveries, building upon the achievements of previous NASA missions.

August 8, 15:00-15:30 - Afternoon Poster Session S 390-6

Parker Solar Probe: An Overview of the MissionAchievementsand Future Prospects

Nour E. Raouafi

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NASA's Parker Solar Probe is now entering the pivotal phase of its prime mission, marking an exciting milestone for this remarkable endeavor. Since its launch on 12 August 2018, Parker has successfully completed 18 out of its scheduled 24 orbits around the Sun, venturing as close as 11.4 solar radii from the Suns center. On 6 November 2024, it will fly by the planet for the seventh and last time, setting it up for the ultimate orbit with a perihelion of 9.86 solar radii on 24 December 2024. The mission's primary science goal is to determine the structure and dynamics of the Sun's coronal magnetic field, understand how the solar corona and wind are heated and accelerated, and determine what processes accelerate energetic particles. Throughout its journey, the mission has made remarkable advancements in its science objectives and crucial discoveries regarding previously unknown solar wind phenomena. As the mission progresses, the intensifying solar activity leading up to its cycle maximum has brought forth new and intriguing properties within the near-solar environment. These distinctive characteristics mark a significant departure from the relatively tranquil period observed during the mission's initial three years. I will present an overview of the mission's current status, its remarkable scientific achievements, and the exciting prospects awaiting us as we conclude this seven-year primary science phase.

August 8, 15:00-15:30 - Afternoon Poster Session S 390-6

Multifractal Domain and Machine Learning for the Analysis of Space Weather

James Wanliss, Stephen Ojo

Anderson University, SC

Space weather can cause temporary and unpredicted electrical interruption in systems on and around the earth. Thus developing early warning systems and extension of forecasting time is critical in real-world applications. Appropriately tuned convolutional neural networks (CNNs) can realize long-term dependencies in physical data. We apply the PyTorch machine learning (ML) framework to several metrics of space weather with novel multifractal measure statistical functions as input. We find that different combinations of features and classifiers produce different results. We employ a grid search-based hyperparameter tuning method in a novel temporal CNN framework not heretofore demonstrated in space weather research.

August 8, 15:00-15:30 - Afternoon Poster Session S 390-6

Applied artificial intelligence for science & exploration enables by public-private partnerships

Madhulika Guhathakurta

NASA

The recent advances in Artificial Intelligence (AI) capabilities are particularly relevant to NASA science and exploration goals because there is growing evidence that AI techniques can improve our ability to model, understand and predict our environment using the petabytes of data already within NASA archives. I will talk about the Frontier Development Lab (FDL) which is an AI research accelerator that was established to apply emerging AI technologies to space science challenges which are central to NASA's mission priorities and provide some examples.Various programs held over the past eight years have focused on AI based science opportunities within the fields of Heliophysics and Space Weather. The program is an 8-week concentrated R&D deep-dive process using the latest developments in machine learning and access to cutting-edge academic research - and enormous compute resources provided by FDLs commercial AI partners - as well as detailed industry partner case studies, showcasing the potential application of AI to space challenge domains. FDL uses sprint methodologies championed by Silicon Valley start-up culture for faster results; places emphasis on interdisciplinary teams for better research quality and viability, and public-private partnerships to lower the costs of high-risk innovation within an expensive technology domain. FDL results will be shared that demonstrate the power of bridging research disciplines and the potential that AI/ML has for supporting research goals, improving on current methodologies, enabling new discoveries, while doing so in accelerated timeframes.

August 8, 15:00-15:30 - Afternoon Poster Session S 390-6

Multi-point view of the Suns magnetic field: Results of co-observations by SO/PHI on Solar Orbiter with telescopes observing along the Sun-Earth line

Sami Solanki

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SO/PHI (the Polarimetric and Helioseismic Imager on Solar Orbiter) is the first magnetograph ever to leave the Sun-Earth line. Consequently, it is not surprising that co-observations between SO/PHI and telescopes observing along the Sun-Earth line have provided a number of novel and unique results. Examples of such results are listed below.

- First synoptic maps of the solar magnetic field produced in only 16 days, compared with the standard 27 days, thus providing more up to date maps of the magnetic field
- First resolution, without imposing additional assumptions, of the 180 degrees ambiguity in the magnetic field vector
- First tracking of the magnetic field of active regions for longer than 10-12 days without significant interruptions
- First direct validation of far-side helioseismology and its calibration in terms of magnetic flux (important for longer term predictions of space weather)
- First stereoscopic determination of the Wilson depression of a sunspot
- First reliable measurements of facular brighteness near the solar limb, important not just for solar irradiance studies, but also for better characterization of exoplanets
- First measurements of both horizontal and vertical velocities in solar p-mode oscillations;
- Identification of a potential solution of the open flux enigma, i.e. why the heliospheric magnetic flux is a factor of >2 larger than the open magnetic flux measured on the Sun.

A selection of the most exciting such firsts will be presented. Additionally, it will be pointed out how combining SO/PHI data with Earth-based and near-Earth observational resources will continue to lead to breakthrough results.

August 8, 15:00-15:30 - Afternoon Poster Session S 390-6

Exploring convolutional neural networks for classification and segmentation of evolving granular structures in the solar surface

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Solar granulation is the visible signature of convective cells emerging from the upper convective zone towards the solar surface. High-resolution images have revealed the complexity of the granulation, evidencing special phenomena such as exploding granules or granular lanes, which are known to be directly related to the emergence of small-scale magnetic flux. Unveiling the nature of magnetic emergence in granules requires extensive statistical studies. The development of new automatic tools has become crucial to perform statistics on a large amount of data expected by new/upcoming instrumentation: DKIST or Sunrise III.

In this contribution, we present the current advances of our classification algorithm of solar granulation based on neural networks including the exploration of recurrent modules for covering the temporal dimension. An initial model was tested using U-net architecture in a supervised approach using the continuum intensity of the IMaX instrument onboard the Sunrise I and their corresponding segmented maps. We study the performance of this approach to assess the versatility of the U-Net architecture for single-frame segmentation. We found an interesting potential of the U-Net to identify granules reaching matching in pixels greater than 80%, achieving high levels of accuracy in the identification of the intergranular network and allowing the effective separation of granular morphologies. We identify per-class accuracy levels of around 60% in single snapshots which are substantially reduced when temporal sequences are included as extra channels. Recurrent modules added within the deep layers seem to improve the prediction accuracy compared with the previous case.

August 8, 15:00-15:30 - Afternoon Poster Session S 390-6

ML-based Ionospheric TEC maps for enhanced K-band VLBI

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Very Long Baseline Interferometry (VLBI) is a powerful technique in radio astronomy and geodesy that enables the precise measurement of the positions of celestial objects, positions on Earth, and the Earth's orientation in space. The International Celestial Reference Frame (ICRF) forms the basis for all positional astronomy and serves as the foundational reference frame for all Earth observations. Currently realizations of the ICRF are based on dual-frequency VLBI observations on the S- and X-band (2.3 and 8.4 GHz) and on single-frequency K-band (24GHz) observations. The higher frequency K-band observations show certain advantages like a higher resolution and a more compact active galactic nuclei (AGN) source morphology. However, the accuracy of K-band astrometric solutions is currently limited by the lack of dual-band observations. Dual-band observations are necessary to correct for ionospheric effects. For a high-quality data analysis, the ionospheric effect needs to be corrected based on external information.

We therefore develop a novel ionosphere model based on machine learning (ML) and apply it to correct ionospheric effects in VLBI K-band measurements. Vertical total electron content (VTEC) estimates from Global Navigation Satellite System (GNSS) as well as space weather indices serve as input data. An ML model based on fully connected neural networks learns the spatial relationship between location and VTEC. We achieve a mean accuracy of 2 TECU for global spatial interpolation during high activity solar conditions. Based on the corrected VLBI observations, a K-Band CRF is calculated to compare the impact of the ML ionosphere model and traditional ionosphere models.

August 8, 15:00-15:30 - Afternoon Poster Session S 390-6

What Do We Know About the Suns Polar Fields?

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The high latitude magnetic field polarity of the Sun changes sign near the maximum of each activity cycle, and we are observing the reversal of Cycle 25 now. The flip happens when magnetic flux from early-cycle active regions migrates from low latitudes to high, changing the dominant polarity. Long-lasting following-polarity patterns move poleward and first erode, then reverse, and finally strengthen the new polar cap. The change is not instantaneous or smooth and varies from hemisphere to hemisphere and cycle to cycle. The details depend on the transport of surface flux elements and the remnant field from the previous cycle. Observations from Cycles 21-25 from the Wilcox Solar Observatory show how the two hemispheres differ and how the overall field strength changes in time. Higher resolution observation from the Helioseismic and Magnetic Imager instrument on the Solar Dynamics Observatory (HMI/SDO) provide more detail about the reversals in Cycle 24 and 25. But one pole or the other is obscured at any given time due to the inclination of the ecliptic, and both the magnetic field and surface dynamics near the poles are difficult to observe from the solar equator. Observations from another vantage point are critical.

August 8, 15:30-17:00 - Afternoon Oral Session S 390-9

The Solaris Mission: A focused solar polar view from outside the ecliptic plane

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Solaris is a transformative Solar Polar mission concept to address crucial outstanding questions that can only be answered from a polar vantage. Solaris will image the Sun's poles from 75 latitude, providing new insight into the workings of the solar dynamo and the solar cycle, which are at the foundation of our understanding of space weather and space climate. Solaris will also provide enabling observations for improved space weather research, modeling and prediction, revealing a unique, new view of the corona, coronal dynamics and CME eruptions from above the ecliptic plane.

The Solaris mission design is an expanded/enhanced version of the mission design from the MIDEX Phase A study of the same name. Solaris includes both remote sensing and in-situ instruments that are essential to address fundamental questions that can only be answered from a polar perspective. Solaris 10 yr mission covers the solar cycle and achieves multiple solar polar passes using a simple, ballistic trajectory. Solaris is ready to go now, moving Heliophysics forward at a critical time when models and computing power are ideally suited to capitalize on new polar observations. Solaris uses existing technology and can stand alone as a single spacecraft mission targeting questions that cannot wait, or act as the first element of a dis-aggregated constellation mission.

August 8, 15:30-17:00 - Afternoon Oral Session S 390-9

The Upcoming Age of New Space Coronagraphs: Perspectives for Joint Science with ASPIICS, CODEX, and Metis.

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In 2024, the coronagraphs ASPIICS and CODEX will be launched on the formation flying PROBA-3 ESA mission and on the ISS with a NASA-KASI-INAF mission, respectively.

The 150-m separation between the formation-flying Coronagraph and Occulter satellites of PROBA-3 will allow long-duration, eclipse-like imaging of the inner corona, down to heliocentric heights of 1.1 solar radii. Besides the cold (1.e+4 K) He I D3 587.6 nm, and hot (2.e+6 K) Fe XIV 530.3 nm emission-lines, ASPIICS will image the visible-light, broadband polarized brightness (pB) of the K-corona.

CODEX will measure the K-coronal intensity ratios at 390 nm and 410 nm where the strong absorption lines are concentrated in the photospheric spectrum, i.e., Ca II lines and the G band. The shape of the continuous coronal spectrum can offer a direct measure of the coronal electron temperature.

The inner field-of-view of ASPIICS will complement that of Metis, already operational on Solar Orbiter since 2020. Additionally, The coronal electron temperature from CODEX will provide a critical physical parameter for the Metis Doppler-dimming diagnostics of the solar wind speed. The presentation will review the perspective opportunities for joint science with Metis, ASPIICS and CODEX.

August 8, 15:30-17:00 - Afternoon Oral Session S 390-9

Solar Close Observation and Proximity Experiments (SCOPE) Mission Concept

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The region close to the Sun is a totally unknown world to us, many important processes and phenomena occurring there are completely imperceptible on the Earth, and it is still an uninhabited zone for the deep space mission. This work is to introduce an unprecedented deep space mission that will enter the uninhabited zone, solving the puzzles that have challenged the solar physics society for around a century. These puzzles are related to the mechanisms for the solar eruption, detection of the coronal magnetic field, as well as the mechanism of the corona heating. The spacecraft will reach to the location closer to the Sun than the Parker Solar Probe would reach on an orbit of larger inclination to the ecliptic plane than the Solar Orbiter. The associated scientific goals include: 1. Entering the central structure of the energy release driving the solar eruption, performing in situ measurements of physical properties of the structure, and solving the problem of mechanisms of solar eruptions; 2. Acquiring the true thickness of the reconnecting current sheet connecting a coronal mass ejection to the associated solar flare, and renovating the classical theory and the physical scenario regarding the large-scale of magnetic reconnection; 3. Acquiring the coronal magnetic field via in situ measurement, obtaining unique evidence for identifying mechanisms of the corona heating, observing closely the polar magnetic field and plasma, revealing the role of the polar magnetic field and plasma in governing the global behavior of the solar activity.

August 8, 15:30-17:00 - Afternoon Oral Session S 390-9

Co-ordinated observing plans for Aditya L1 and other space platforms

Dipankar Banerjee

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Aditya L1 mission is the first observatory class solar mission from the Indian Space Research organization, launched in 2nd September 2023. The L1 insertion took place on 6th January 2024. With a combination of four remote sensing and 3 in situ instruments covering multi-wavelength it provides a unique opportunity to have joint observations with other co temporal missions. The first results from Aditya payloads will be presented during the invited plenary talk, but I will focus on the possible joint observations from other vantage points from space and ground. There will be window of opportunity for proposing joint observational campaigns with Aditya by the end of this year. So possible synergy of some transient studies with complimentary payloads on Solar orbiter, IRIS and ASPICS on PROBA3 with a combination of imaging and spectroscopic capabilities will be highlighted.