17th European Solar Physics Meeting ESPM-17

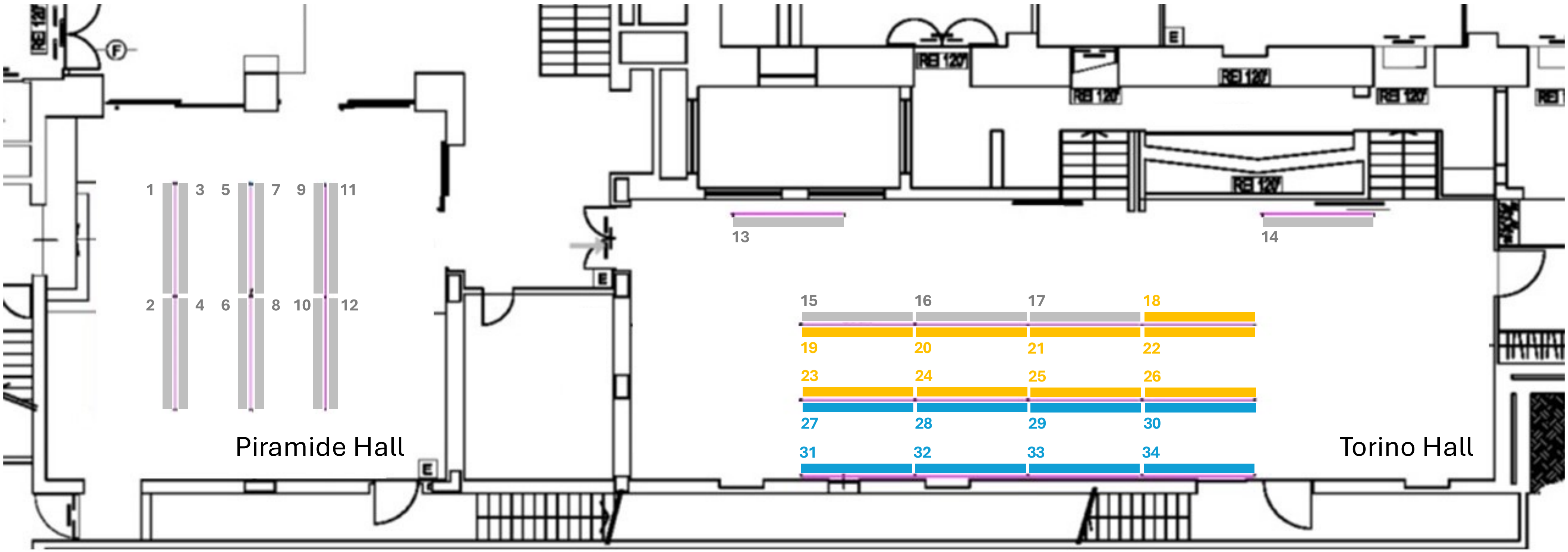
Report of Contributions

POSTER SESSION 2

TOPICS 4, 5, 6

Wednesd 11,	10:30-11:30
Thursday 12,	10:25-11:25
	15:50-16:50
Friday 13,	10:35-11:35

Poster Session 2



Topic 4: Multi-scale energy release, flares and coronal mass ejections
Topic 5: Diagnostic tools and numerical methods in solar physics
Topic 6: Space weather and the solar-heliospheric connections

Poster session 2 (September 11-13)

Topic 4: Multi-scale energy release, flares and coronal mass ejections

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7	Michael Haahr	*Towards Realistic Solar Flare Models*	1 A
8	Shantanu Jain	*Dimming Inferred Estimation of CME Direction - DIRECD*	1 B
17	Sivakumara Tadikonda	*Wide-Field EUV Image Campaigns with GOES Solar UltraViolet Imager*	1 C
22	Luke Majury	*Spectral Irradiance Variability in Lyman-alpha Emission During Solar Flares*	1 D
34	Haocheng Yu	*Sun-as-a-star Analysis of Simulated Solar Flares*	2 A
35	Elena Dzifcakova	*Model of the Si IV emission at the loop footpoints heated by an electron beam*	2 B
40	Paloma Jol	*Deep Learning study into sunspot evolution for use in flare forecasting*	2 C
47	Henri Lamarre	*Bridging the gap between ab initio MHD modelling and avalanche models of solar flares*	2 D
52	Ruhann Steyn	*A multi-wavelength investigation into the photospheric effects of a solar flare on 1 July 2012 using Swedish Solar Telescope observations*	3 A
61	Zheng Sun	*Fast Downflows Observed during a Polar Crown Filament Eruption*	3 B
63	Dong Li	*Localising QPPs in HXR, microwave and Lya emissions of an X6.4 flare*	3 C
65	Tomasz Mrozek	*Kink-and-Disconnection Failed Eruption in 3D*	3 D
69	Ross Pallister	*Investigating the effect of thermal collisional plasma and turbulent acceleration in a simulated coronal acceleration region on heliospheric electron spectra*	4 A
73	Gabriele Cozzo	*Forward and MHD modeling of nanojets driven by magnetic reconnection during MHD avalanches*	4 B
77	Sascha Ornig	*White-light Emission in the F-CHROMA Grid*	4 C
84	Alex Pietrow	*On the detection of solar flares in a Sun-as-a-star setting*	4 D
88	Runbin Luo	*Fast Magnetic Reconnection Excites a Global Blast Wave in the Solar Corona*	5 A
89	Wensi Wang	*Observations of photospheric signatures for pre-eruptive coronal structures*	5 B
90	Stefan Purkhart	*The Rapid Filament Restructuring in AR 12975 on 28 March 2022 and its Connection to the Subsequent Eruption*	5 C
94	Oliver Rice	*Potential Predictions of Magnetic Flux Rope Eruptions*	5 D
97	Tatiana Kaltman	*Locating sites of magnetic energy release in the 2022-10-02 X-class flare*	6 A
106	Zhuofei Li	*Key Roles of External and Internal Reconnection in Small-Scale Solar Events*	6 B
111	Daniel Müller	*Solar Orbiter: Science highlights and mission status*	6 C
125	Alessandro Bemporad	*First detection of small-scale helical flows in the void of a Coronal Mass Ejection with high-cadence coronagraphic images acquired by the Metis coronagraph on-board Solar Orbiter*	6 D
142	Sara Mulas	*Exploring the variable spectra and magnetic fields of the Active Regions in the chromosphere through high-frequency radio imaging: gyro-resonance emission and flare forecasting*	7 A
144	Shuting Li	*Mysterious heating source inside an erupting prominence as observed by Solar Orbiter/Metis and ASO-S/SDI instruments*	7 B
149	Pranjali Sharma	*Statistical study of NUV continuum enhancement in Solar flares*	7 C
150	Preity Sukla Sahani	*Metis Observations of Geoeffective Solar Events*	7 D

153	Maxime Dubart	*Beam-driven evaporation in 2.5D flare simulations with an asymmetric magnetic field configuration*	8 A
154	Clementina Sasso	*Analysis of solar eruptive events captured by Solar Orbiter during the "Eruption Watch" coordination campaigns.*	8 B
161	Alena Zemanova	*Slowly Positively Drifting Bursts generated by Large-Scale Magnetic Reconnection*	8 C
164	Yue Zhang	*Signature of Self-organized Criticality in Flaring Current Sheets*	8 D
165	Muriel Zoë Stiefel	*Flare accelerated electrons detected at anchor points of erupting filaments*	9 A
166	Sanna Normo	*Investigating the band-splitting of a type II solar radio burst using LOFAR imaging and spectroscopy*	9 B
170	Graham Kerr	*The Lyman Lines During Solar Flares: Solar Orbiter/SPICE's first high-cadence flare observation*	9 C
172	Debesh Bhattacharjee	*On the Application of Warm Target Model in Investigating the Time Evolution of Solar Flares*	9 D
173	Nancy Narang	*Extreme–ultraviolet transient brightenings in the quiet-Sun corona observed with Solar Orbiter/EUI*	10 A
174	Jana Kasparova	*Reconnection within the erupting flux rope during a solar flare*	10 B
177	Chen Xing	*Understanding Precursors of Coronal Mass Ejections and Flares*	10 C
179	Steffen Hallmann	*Solar radio flare observations with the Radio Neutrino Observatory Greenland (RNO-G)*	10 D
182	Cis Verbeeck	*EUI onboard Solar Orbiter: unique data for high resolution, far corona and connection science*	11 A
183	Amaia Razquin Lizarraga	*Coronal dimmings associated with the May 2024 flare/CME events from AR 13664*	11 B
193	Moritz Meyer zu Westram	*Solar Flare Forecasting Utilizing Deep Survival Analysis*	11 C
208	Francesco Frascella	*Metis Solar Wind Speed Maps during the first half of the 25th solar cycle: the role of the assumed electron temperature radial profile*	11 D
210	Alexander Nindos	*Magnetic helicity and energy budgets of jet events from an emerging solar active region*	12 A
211	Can Wang	*Radiative Magnetohydrodynamic Simulation of the Confined Eruption of a Magnetic Flux Rope: Unveiling the Driving and Constraining Forces*	12 B
217	Juraj Lorincik	*Observational discovery of slip-running reconnection during a solar flare*	12 C
218	Abril Sahade	*Partial eruptions by breakout reconnection*	12 D
234	Jianchao Xue	*Association between a Failed Prominence Eruption and the Drainage of Mass from Another Prominence*	13 A
237	Anna Kępa	*Soft X-ray Solar Flare Spectroscopy: Synergistic Observations from XSM and STIX*	13 B
238	Augustin André-Hoffmann	*Is the sub-flaring activity of a solar active region a good whistleblower for impending eruption?*	13 C
240	Yingjie Luo	*Flare Accelerated Electrons in Kappa-Distribution from X-Ray Spectra with Warm-Target Model*	13 D
250	Hannah Collier	*Disentangling coronal hard X-ray emission from the total signal through stereoscopic observations with Solar Orbiter/STIX and FERMI/GBM*	14 A
256	Brenda Dorsch	*Modelling of Coronal Mass Ejections Through the Novel FRi3D Model and the Effect of Twist Parameter*	14 B
266	Säm Krucker	*Hard X-ray Flare observations by Solar Orbiter/STIX*	14 C
275	Zhentong Li	*The imaging evidence of low-energy cutoff and the status of spectral cross-calibration of HXI*	14 D
276	Ketaki Deshpande	*Complex interactions of the shock wave and ambient coronal structures*	15 A
288	Ignasi Josep Soler Poquet	*Ellerman Bomb detection in SST and SDO observations with Deep Learning.*	15 B
291	David Paipa Leon	*Energy diagnostics of flare-accelerated electron beams with X-ray and Radio data from Solar Orbiter*	15 C
295	Aneta Wisniewska	*Long-Period of Plasma and Magnetic-Helicity Oscillation Prior to Three C-class Flares*	15 D

296	Jonah Klowss	*Investigating the effect of statistically-averaged helicity condensation on ambient increase in the Solar Open Flux*	16 A
297	Anmol Kumar	*Propagation and reflection of MHD waves in the solar wind*	16 B
304	Zurab Vashalomidze	*Infrared spectropolarimetry of C class solar flare*	16 C
312	Federica Frassati	*3D recostruction of a CME with polarimetric technique*	16 D
328	Artem Ulyanov	*Correlation approach to nanoflare heating diagnostics*	17 A
338	Vishal Singh	*Probing the substructures of solar flare ribbons*	17 B
342	Alessandro Liberatore	*Non-Radial and Multiple Interacting CMEs: A Multi-Spacecraft Perspective Combining Coronagraphs and Heliospheric Imagers*	17 C
343	Ioannis Kontogiannis	*The extremely strong photospheric electric currents of active region NOAA 13664*	17 D

Topic 5: Diagnostic tools and numerical methods in solar physics

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16	Lilli Nadol	*Magnetic field extrapolation using analytical 3D MHS equilibrium solutions*	18 B
25	Raveena Khan	*Exploring EUV coronal diagnostics: the Hanle effect of Ne VIII 770 Å*	18 C
36	Elena Dzifcakova	*Multi-Ionization and Suppression of Dielectronic Recombination for the ionization equilibria of kappa-distributions*	18 D
43	Lami Chan	*Global Coronal Plasma Diagnostics Based on Multislit Extreme-ultraviolet Spectroscopy*	19 A
44	Johannes Hölken	*Spectroflat: A generic spectrum and flat-field calibration library for spectro-polarimetric data*	19 B
45	Jithu J. Athalathil	*Surface Flux Transport Modelling using Physics Informed Neural Networks.*	19 C
51	Amanda Romero Avila	*Direct Estimates of the Wilson Depression with Stereoscopic Observations of SO/PHI and SDO/HMI*	19 D
78	Dusan Vukadinovic	*Inference of atomic line parameters from quiet-sun observations at 1.56 microns*	20 A
81	Giulio Del Zanna	*Spectral diagnostics of the solar corona*	20 B
95	Edvarda Harnes	*Chromospheric Fe I lines in the NUV solar spectrum*	20 C
98	Dimitri Arramy	*Jacobian-Free Newton-Krylov method for multilevel NLTE radiative transfer problems*	20 D
100	Mats Kirkaune	*Simulating fast on-the-fly scans of the solar disk with the Atacama Large Aperture Submillimeter Telescope (AtLAST)*	21 A
110	Mariarita Murabito	*Waves reflection linked with FIP bias*	21 B
130	Ahcene Bouabedellah	*Magnetic Rayleigh-Taylor instability in Solar Atmosphere: Downward Magnetic Flux Transport*	21 C
139	Feng Chen	*Realistic Simulations of Real Active regions*	21 D
159	Christian Palmroos	*A New Method for Finding SEP Event Onset Times and Evaluating Their Uncertainty: Poisson-CUSUM-Bootstrap Hybrid Method*	22 A
162	Francesco Carella	*Clustering of the Solar Wind at 1 AU: Reconnection and the Ambient Solar Wind*	22 B
175	Cristina Mandrini	*Comparison of Methodologies to Estimate the Tilt Angle in Solar Active Regions*	22 C
187	Sondre Vik Furuseth	*Benchmarking Solar Simulations: An Analytical Solution for Non-Linear Diffusivity*	22 D
200	Mirkan Yusuf Kalkan	*The use of artificial intelligence techniques in the prediction of the solar activity cycle 25*	23 A
203	Christoph Schirninger	*Deep learning image burst stacking to reconstruct high-resolution ground-based solar observations*	23 B
207	Ilaria Ermolli	*Ca II K brightness as a function of magnetic field strength and characteristics of the observations*	23 C
214	Fan Zhang	*Physically-consistent Riemann solvers for accurate and robust MHD modelling with low plasma beta*	23 D

216	Evangelia Deliporanidou	*CHIANTI version 11 - advanced ionization equilibrium models: density and charge transfer effects*	24 A
226	Johann Hirzberger	*The highest resolution full-disk magnetic field maps, obtained with SO/PHI*	24 B
252	Michelle Galloway	*Development of a solar/stellar wide-spectral coverage polarimeter for investigating flare energetics*	24 C
257	Yong Zhang	*Parameters' Maps Generated by Intensity of the Lyman-beta and Lyman-gamma Lines from SPICE Data and Non-LTE Modeling*	24 D
269	Vartika Pandey	*Atmospheric temperature and density stratification for magneto-hydrodynamic models and spectro-polarimetric inversions*	25 A
277	Sergei Shestov	*Radiometric cross-calibration of HRI/EUI on Solar Orbiter and AIA/SDO*	25 B
311	Vincenzo Chiaramida	*MOF: the Ground Support to Metis Data and Operations*	25 C
319	Ioannis Kontogiannis	*COCOMAG: color-coded magnetograms as probes of active region evolution and complexity*	25 D
325	Marta Casti	*Investigating the relation between the measured solar wind speed and the extrapolated magnetic field configuration in the solar corona*	26 A
326	Ariadna Rosario Calcines	*State-of-the-art Image Slicer developments to Enable 2D Extreme Ultraviolet Imaging Spectroscopy in Seconds.*	26 B
339	Jun Chen	*FastQSL: A Fast Computation Method for Quasi-separatrix Layers*	26 C

Topic 6: Space weather and the solar-heliospheric connections

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20	Michael Marschollek	*Machine learning time series causal effect analysis of the interplanetary magnetic field's Bz component and geomagnetic Ap on cardiovascular health event frequency*	27 A
23	Xiaomeng Zhang	*Insights into the Rotation and Eruption of Magnetic Flux Ropes Influenced by External Toroidal Magnetic Fields*	27 B
27	Brigitte Schmieder	*Deceleration of CMEs between Mercury and Earth tested by EUHFORIA/ICARUS MHD simulations*	27 C
76	Anwesha Maharana	*Horseshoe CME model in EUHFORIA for geo-effectiveness predictions*	27 D
87	Luis Linan	*Forecasting the propagation and evolution of CMEs using the space weather simulation chain: COCONUT + EUHFORIA*	28 A
99	Alberto Paolo Pellizzoni	*Monitoring of the solar atmosphere through radio imaging in the 18-100 GHz band: recent results and future challenges*	28 B
109	Jingjing Wang	*A Strong-flare Prediction Model Developed Using a Machine-learning Algorithm Based on the Video Data Sets of the Solar Magnetic Field of Active Regions*	28 C
114	Vanessa Mercea	*Satellite Orbital Decay and Solar Wind Interactions: A Data Driven Case Study of May 2024 Space Weather Events*	28 D
115	Angelos Valentino	*Modeling of non-radially propagating CMEs and forecasting their arrival time at Earth*	29 A
118	Stephan G. Heinemann	*On the Origin of the sudden Heliospheric Open Magnetic Flux Enhancement during the 2014 Pole Reversal*	29 B
124	Gaetano Zimbardo	*The September 5, 2022, coronal mass ejection characterized by remote observations, numerical simulations, and in situ measurements*	29 C
127	Samir Nait Amor	*Observations and Numerical Simulations of the Effects of the Gamma Ray Burst 221009A on the Lower Ionosphere*	29 D
129	Fethia Kerrache	*Mediterranean D-region ionosphere response to solar flares events*	30 A
190	Panagiotis Gonidakis	*Predicting Soft X-ray Emissions for Solar Flare Forecasting Using a Self-Supervised CNN Trained on Solar Dynamics Observatory Data*	30 B
196	Aarushi Rawat	*Denoising Helioseismic Far-Side Images with Spatial and Temporal filters*	30 C
227	Monica Laurenza	*The CAESAR project: Comprehensive spAce wEather Studies for the ASPIS prototype Realization*	30 D
231	Farhad Daei	*Using Data-driven time-dependent Magnetofrictional modeling to initiate Magnetohydrodynamic simulations of coronal active regions*	31 A

236	Shifana Koya	*Understanding the magnetic field evolution of the 10 March 2022 Coronal Mass Ejection*	31 B
239	Eleanna Asvestari	*Comparative analysis of the open and closed field topologies reconstructed by different coronal models*	31 C
241	Yuankun Kou	*Observations and modeling of solar flare energetic electrons in hard X-ray, radio and in-situ near 1 AU*	31 D
258	Dario Del Moro	*The ASPIS prototype: the Database, the Web App, and the Python Package*	32 A
260	Jasmina Magdalenic	*Solar wind modelling with EUHFORIA and the PSP observations*	32 B
285	Raffaele Reda	*Cross-scale phase relationship of solar activity with solar wind parameters: a Space Climate focus*	32 C
290	Mattia Sangalli	*Magnetohydrodynamic drag simulations for a coronal mass ejection*	32 D
292	Sven Wedemeyer	*Solar observations with the Atacama Large Aperture Submillimeter Telescope (AtLAST)*	33 A
300	Maria Pia Di Mauro	*Using the Sun as Rosetta stone to study the properties of other solar-like systems*	33 B
303	Andrea Lani	*Modeling the Propagation of CMEs with COCONUT: Implementation and application of the RBSL Flux Rope Model*	33 C
309	Federico Pinna	*Heliospheric Space Weather Centre tools for space weather monitoring*	33 D
314	Ronish Mugatwala	*A catalog of CME-ICME lineup events*	34 A
315	Luca Giovannelli	*Sun cubE onE (SEE): a CubeSat Mission for High-Energy Solar Observations*	34 B
329	Sophie Boswell	*Kinetic Models of Solar Wind Current Sheets*	34 C
331	Philippe-A. Bourdin	*Estimating the helicity and electromotive force with SolarOrbiter in-situ data of an iCME*	34 D

Contribution ID: **7** Type: **Poster**

Towards Realistic Solar Flare Models

Solar flares are complex multiscale phenomena that demand modeling strategies capable of precisely capturing processes at both the microscale and macroscale. At the microscale, kinetic models such as the Particle-In-Cell (PIC) method are crucial for an accurate depiction of physical phenomena, especially particle acceleration near reconnection sites. However, the extensive computational demands of full-scale PIC simulations necessitate a more practical approach. A hybrid system is employed wherein Magneto Hydrodynamics (MHD) governs the large-scale dynamics, while PIC is strategically applied to model the critical reconnection processes.

We have developed a PIC solver and integrated it within the DISPATCH framework. DISPATCH organizes the simulation domain into smaller, manageable 'patches'. Each patch operates semi-autonomously, updating based on local conditions, thereby enabling simulation across diverse time and spatial scales. This modular approach not only achieves near-perfect strong and weak scaling but also enables dynamic solver switching, a critical feature for efficiently addressing the vast scale discrepancies characteristic of solar flare phenomena.

Here, we show the initial validation results of our explicit PIC solver, along with our ongoing efforts towards its integration with MHD. We will underscore the significant advancements in our hybrid modeling approach, demonstrating its potential to enhance our understanding and simulation capabilities of solar flares.

Primary author: HAAHR, Michael (University of Oslo - Institute of Theoretical Astrophysics)

Co-authors: Prof. GUDIKSEN, Boris V. (University of Oslo - Institute of Theoretical Astrophysics); NORDLUND, Åke (University of Copenhagen)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **8** Type: **Poster**

Dimming Inferred Estimation of CME Direction - DIRECD

Coronal mass ejections (CMEs) are powerful solar events involving the expulsion of plasma and magnetic fields, significantly impacting Space Weather. Traditional coronagraphs face challenges in accurately measuring the early evolution of Earth-directed CMEs due to projection effects. Coronal dimmings, characterized by localized reductions in extreme-ultraviolet (EUV) and soft X-ray emissions, serve as crucial indicators of CMEs in the low corona. These dimmings arise from mass loss and expansion during the eruption. This study introduces DIRECD (Dimming InfeRred Estimate of CME Direction), a new method to estimate initial CME propagation direction based on dimming expansion. The approach uses 3D CME simulations with a geometric cone model, exploring parameters like width, height, source location, and deviation from the radial direction. The primary direction of dimming expansion is identified, and an inverse problem is solved to reconstruct a series of CME cones at different heights, widths, and deviations. The 3D CME direction is determined by comparing the CME projections onto the solar sphere with the dimming geometry. Validated through case studies on October 1, 2011, and September 6, 2011, the DIRECD method reveals the initial propagation directions of CMEs which are close to that derived from the 3D tie-pointing of the CME bubble observed in EUV (lower corona) and from the GCS 3D modeling of the white-light CME (higher corona). Additionally, these findings are consistent with the multi-viewpoint coronagraph observations of the CMEs from both SOHO and STEREO. The research highlights the potential of coronal dimming data for early estimation of CME direction.

Primary authors: JAIN, Shantanu (Skolkovo Institute of Science and Technology); Dr PODLADCHIKOVA, Tatiana (Skolkovo Institute of Science and Technology); CHIKUNOVA, Galina (Skolkovo Institute of Science and Technology); DISSAUER, Karin (NorthWest Research Associates, Boulder CO, USA); VERONIG, Astrid (University of Graz)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **16** Type: **Poster**

Magnetic field extrapolation using analytical 3D MHS equilibrium solutions

With current observational methods it is not possible to directly measure the magnetic field in the solar corona with great accuracy. Therefore, coronal magnetic field models have to rely on extrapolation methods using photospheric magnetograms as boundary conditions. In recent years, due to the increased resolution of observations and the need to resolve non-force-free lower regions of the solar atmosphere, there have been increased efforts to use magnetohydrostatic (MHS) field models instead of force-free extrapolation methods. Although numerical methods to calculate MHS solutions can deal with non-linear problems and hence provide more accurate models, analytical three-dimensional MHS equilibria can also be used as a numerically relatively "cheap" complementary method [T. Wiegelmann et al.(2015), T. Wiegelmann et al.(2017)]. We present an extrapolation method based on a family of analytical MHS equilibria that allows for a transition from a non-force-free region to a force-free region [T. Neukirch and T. Wiegelmann (2019)]. In a subset of cases, asymptotic solutions can be used to make the method numerically more efficient. We shall present some examples of applications of the method.

Primary authors: NADOL, Lilli (University of St Andrews); Prof. NEUKIRCH, Thomas (University of St Andrews)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **17** Type: **Poster**

Wide-Field EUV Image Campaigns with GOES Solar UltraViolet Imager

Traditional approaches to tracking solar outflows for space weather forecasting rely primarily on coronagraph images, which generally observe the solar corona above a minimum height of about 2.5 solar radii. Extreme ultraviolet (EUV) imagers have been widely used to characterize features on the solar disk, but their limited fields of view have prevented their use for tracking outflows through the inner and middle coronae. A series of off-point campaigns with the GOES 16-18 Solar Ultraviolet Imager (SUVI) between 2018 and 2024 have provided an opportunity to assess the value of extended EUV images for space weather forecasting applications. These new results demonstrate that wide FOV EUV images are useful for characterizing the early onset of eruptive events and tracking smaller outflow into the solar wind. Because CMEs generally experience the bulk of their acceleration below the height of white light coronagraphic observations, these images provide information about the origins of these events that has not been traditionally available. Together with coronagraphic measurements, EUV images enable connecting CMEs back to their source regions. Of note are the two campaigns in 2021 and 2024 that were conducted to coordinate with the Solar Orbiter and Parker Solar Probe perihelion observations. The April 2024 campaign provided a trove of valuable data due to the active Sun. The upcoming campaign on GOES-19 has the added benefit of a Compact Coronagraph sharing the same Sun-pointing platform with SUVI. Here, we present these new SUVI observations and discuss their potential use in space weather operations.

Primary author: TADIKONDA, Sivakumara (Science Systems and Applications, Inc)

Co-authors: Mr KRIMCHANSKY, Alexander; Dr BETHGE, Christian (NCEI); Dr SEATON, Daniel B.; Mrs DAHYA, Melissa; Mr MCKIM, Stephen A.

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **20** Type: **Poster**

Machine learning time series causal effect analysis of the interplanetary magnetic field's Bz component and geomagnetic Ap on cardiovascular health event frequency

Associations between space weather and events on Earth, e.g., geomagnetic perturbations affecting power grids, are well-known. Effects on human health and physiology are less well investigated, and current evidence, suggesting, e.g., less frequent cardiovascular events during phases of high geomagnetic disturbance, builds on small patient cohorts and a wide array of statistical tests. Recently, the availability of large space weather time series along with huge epidemiologic observational databases facilitates evidence synthesis by employing advanced machine learning approaches to uncover associations between both.
The objective is to investigate potential causal effects of the solar wind's southward IMF component and strong geomagnetic disturbance on cardiovascular health, in particular on cardiac arrest events as a hard endpoint.
Time series of the IMF's Bz component (Wind satellite, L1) and Ap from the year 2015 were merged with emergency service use time data from the U.S. for cardiac arrest events. A causal impact analysis using counterfactual reasoning was performed to test for causal effects of the March 15 CME and the subsequent St. Patrick's day G4 level geomagnetic superstorm, for a 14-day period after the CME.
Statistically significant, negative causal impact on cardiac arrest event frequency in the U.S. are identified for the southward (Bz) IMF component (-7% [-12%, -5%], p=0.001) and Ap (-9% [-10%, -4%], p=0.001).
Results show a significant impact of IMF and geomagnetic disturbance on cardiac arrest frequency in the U.S., potentially due to alterations in the activation of the autonomous nervous system. More research is necessary to uncover mechanistic models.

Primary author: MARSCHOLLEK, Michael (Hannover Medical School, TU Braunschweig)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **22** Type: **Poster**

Spectral Irradiance Variability in Lyman-alpha Emission During Solar Flares

The ultraviolet Lyman-alpha line of neutral hydrogen is the brightest emission line in the quiescent solar spectrum and is a significant radiator of flare energy. The study of spectrally resolved Lyman-alpha flare observations may provide a valuable diagnostic of where flare heating occurs in the solar atmosphere. Despite this potential diagnostic use, most contemporary flare observations in Lyman-alpha are not spectrally resolved. SORCE/SOLSTICE provided flux and wavelength calibrated spectral irradiance measurements of the Lyman-alpha line between 2003 and 2013. A number of these scans coincided with the impulsive phase of major solar flares, several of which were also simultaneously observed by RHESSI. This study focused on two flares of class M5.3 and M8.3, both observed by SOLSTICE and RHESSI. We compared the spectral response of the Lyman-alpha line to the properties of non-thermal electrons driving the line's enhancement. The respective flares had electron beam spectral indices of 3.38 and 7.76, with greater enhancement of the Lyman-alpha line wings relative to the line core for the former flare. Our findings illustrate a positive correlation between electron beam hardness and relative enhancement of the Lyman-alpha line wings compared to its core for flares of similar GOES magnitude. These comparisons of Lyman-alpha spectral emission and electron beam spectral index may help guide and interpret radiative hydrodynamic flare simulations such as RADYN. This research may serve as a baseline study for the advent of spectral Lyman-alpha flare observations anticipated from new instruments coming online during Solar Cycle 25, including Solar-C/EUVST and SNIFS.

Primary author: MAJURY, Luke (Queen's University Belfast)

Co-authors: Dr BUTLER, Elizabeth; Mr GREATOREX, Harry (Queen's University Belfast); Dr MILLIGAN, Ryan (Queen's University Belfast)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **23** Type: **Poster**

Insights into the Rotation and Eruption of Magnetic Flux Ropes Influenced by External Toroidal Magnetic Fields

We perform a data-constrained simulation with the zero-beta assumption to study the mechanisms of rotation and failed eruption of a filament in active region 11474 on 2012 May 5. Our simulation reproduces most observational features very well, e.g., the large-angle rotation, the confined eruption and flare ribbons. We discover two flux ropes in the sigmoid system, an upper flux rope (MFR1) and a lower flux rope (MFR2) grows by tether-cutting reconnection during the eruption, which correspond to the filament and hot channel in observations, respectively. Both flux ropes undergo confined eruptions. The rotation of MFR1 is related to the shear-field component along the axis. The toroidal field tension force and the non-axisymmetry forces confine the eruption of MFR1. We also suggest that the mutual interaction between MFR1 and MFR2 contributes to the large-angle rotation and the eruption failure.

Then, we perform three-dimensional magnetohrdronamic simulations to model the eruption of magnetic flux ropes in the magnetic configuration with and without external toroidal magnetic fields, to examine the mechanisms by which the toroidal magnetic field facilitates flux-rope rotation, and in exploring potential alternative rotation mechanisms beyond the effects of sheared fields and kink instability. The behavior of flux ropes in two simulations exhibits significant contrasts. We indicate that toroidal fields facilitate the flux-rope rotation by promoting the release of the initial twist and amplifying the lateral Lorentz force exerted on the flux rope. In addition, slipping magnetic reconnection between flux-rope field lines and sheared-arcade field lines can also contribute to the rotation.

Primary author: ZHANG, Xiaomeng

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **25**   Type: **Poster**

Exploring EUV coronal diagnostics: the Hanle effect of Ne VIII 770 Å

The Hanle effect refers to the modification of degree of linear polarization and rotation of the plane of polarization of the scattered radiation in the presence of an external magnetic field. In a recent publication, we reported spectral lines in the extreme-ultraviolet (EUV) range that exhibit sensitivity to the unsaturated Hanle effect and are, therefore, inherently sensitive to the vector magnetic field in the solar corona. In our current research, we focus on modeling one such EUV line - Ne VIII 770 Å - and compute the polarization signals induced by resonance scattering. We interpret the modifications in these signals due to collisions and magnetic fields through the Hanle effect. By employing 3D magneto-hydrodynamic models (PSIMAS), we synthesize the polarization maps both on the solar disk and off the limb. The polarization degree (defined as L/I= sqrt(Q^2+U^2)/I) and the rotation angle of the plane of polarization (defined as Az= (1/2) arctan(U/Q)) are simulated through the entire solar cycle 24. By FORWARD modeling the polarization of Ne VIII 770 Å, we have explored its potential as a polarimetric diagnostic for the weak coronal magnetic field. Our study demonstrates that this EUV line can be a useful complement to coronal field diagnostics in the FUV, such as O VI 1032 Å and H I 1216 Å, and off-limb spectropolarimetric measurements in the visible and infrared wavelengths, such as those obtained with the Visible Emission Line Coronagraph (VELC), the Upgraded Coronal Multi-Channel Polarimeter (UCoMP) and the Daniel K. Inouye Solar Telescope (DKIST).

Primary author: KHAN, Raveena (Indian Institute of Astrophysics, Bengaluru)

Co-authors: Dr CASINI, Roberto (High Altitude Observatory, CO, USA); Dr GIBSON, Sarah (High Altitude Observatory, CO, USA); Dr NAGARAJU, K. (Indian Institute of Astrophysics, Bengaluru)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **27** Type: **Poster**

Deceleration of CMEs between Mercury and Earth tested by EUHFORIA/ICARUS MHD simulations

Coronal Mass Ejections (CMEs) are the main drivers of the disturbances in interplanetary space. Then, understanding CMEs is crucial for advancing space weather studies. Assessing the numerical heliospheric model capabilities is crucial, as understanding the nature and extent of the limitations can be used for improving space weather predictions. In a statistics study it was shown that among 28 cases observed by the two spacecraft located near Mercury (MESSENGER) and Earth (ACE), 22 cases show a deceleration of 160 km/s. We test this result by considering two cases using the advanced 3D MHD heliospheric modeling tool Icarus recently developed at CmPA, KU Leuven. Icarus applies the radial grid stretching and adaptive mesh refinement to the computational domain to obtain fast simulations. The source regions for the CMEs were identified, and the CME parameters were calculated and optimized. The results were compared to insitu measurements.
The first CME case erupted on SOL2013-07-09T15:24. The modeled time series were in good agreement with the observations both at MESSENGER and ACE. The second CME case, starting on SOL2014-02-16T10:24 was more complicated, three CME interactions have to be taken into account. The CME-CME interactions were modeled in the Icarus simulations, which reconstructed the observed time series much better than considering only one CME. The deceleration of the CMEs observed between Mercury and Earth and attributed to the accumulation of the solar wind plasma upstream of the ICME was not retrieved in the simulations. The modeled time-series and observations are compared for both CME events.

Primary author: SCHMIEDER, Brigitte (Observatoire de Paris)

Co-authors: Dr DEMOULIN, Pascal (Observatoire de Paris); Prof. POEDTS, Stefaan (KU Leuven); BARATASHVILI, Tinatin (KU Leuven); Dr GRISON, Benjamin (University of Prague)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **34** Type: **Poster**

Sun-as-a-star Analysis of Simulated Solar Flares

Context. Stellar flares has an impact on habitable planets. To study the flares by observations with no spatial resolution, Sun-as-a-star analyses are developed. With the data of Sun-as-a-star observations, a simulation of solar flares is required to provide a systemic clue to the Sun-as-a-star study.

Aims. We aim to develop a model of solar flares and study the relationship between the Sun-as-a-star spectrum with the flare class and location.

Methods. Using 1D radiative hydrodynamics flare model and multi-thread flare assumption, we obtain the spectrum of a typical flare with an enhancement of chromospheric lines.

Results. The preflare-subtracted spectrum of Hα shows an enhanced and shifted component, highly depending on the flare class and location. The velocity sign is well measured by the bisector method. The spectrum of a limb flare tends to be wider and shows a central reversal profile. In particular, we propose two quantities to diagnose the class and location of the stellar flares. Besides, caution must be taken when calculating the radiation energy, since the conversion coefficient from observed flux to energy is dependent on the flare location.

Primary author: YU, Haocheng

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **35** Type: **Poster**

Model of the Si IV emission at the loop footpoints heated by an electron beam

We model Si IV emission originating at footpoints of loops heated by an electron beam. Time dependent plasma parameters (temperature, density, non-Maxwellian beam electron distribution function…) in the transition region are modeled using radiation-hydrodynamical simulations via the FLARIX code for a wide range of the beam parameters. The ionization stages of Si are shown to be out of ionization equilibrium, and also dependent on the electron beam parameters. The Si IV intensities and their evolution are then modelled using a 16-level ion model. The results are compared with Si IV emission observed by IRIS.

Primary author: Dr DZIFCAKOVA, Elena (Astronomical Institute of the Czech Academy of Sciences)

Co-authors: Dr KASPAROVA, Jana (Astronomical Institute of the Czech Academy of Sciences); Dr DUDIK, Jaroslav (Astronomical Institute of the Czech Academy of Sciences)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **36** Type: **Poster**

Multi-Ionization and Suppression of Dielectronic Recombination for the ionization equilibria of kappa-distributions

Kappa-distributions are particle distributions with a Maxwellian core and high-energy tail. They have strong theoretical support and can originate in the in the solar corona and transition region as a result of heating processes. Distributions with high-energy tail influence individual ionization, recombination and collisional excitation rates what affects the ionization equilibrium, populations of the energy levels and finally the line intensities. Now we included to our calculations of the ionization equilibria for the kappa-distributions also the multi-Ionization and suppression of dielectronic recombination. We have showed that the effect of multi-ionization increases with the importance of the high-energy tail of distribution. Reversely, the effect of the suppression of dielectronic recombination on the ionization equilibria decreases with increasing number of high-energy particles. This new ionization equilibria were added into the latest version of KAPPA package (software and database, http://kappa.asu.cas.cz/), what allows us to calculate synthetic spectra and propose diagnostics for kappa-distributions.

Primary author: Dr DZIFCAKOVA, Elena (Astronomical Institute of the Czech Academy of Sciences)

Co-author: DUDIK, Jaroslav (Astronomical Institute of the Czech Academy of Sciences)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **40** Type: **Poster**

Deep Learning study into sunspot evolution for use in flare forecasting

Solar flares are large eruptions of electromagnetic radiation from the Sun which can affect the Earth's atmosphere and the radio communications. Since the delay between the flare event and their near-Earth effects is only 8 minutes, it is essential we can forecast these events in advance. This work aims to train a Deep Learning model to predict flares within a forecasting window. We use images obtained from the Solar Dynamics Observatory (SDO) Space weather HMI Active Region Patch (SHARPs) specifically the radial component of the magnetic field. By using the whole active region image observations as input we want to improve our understanding of the physics leading up to flares and thus also improve our ability to forecast them. We looked at magnetogram images between 2016-2023 with cadence of 24 hours and the corresponding GOES X-ray flux in the next 24 hours to create the image and flare-outcome label pairs. Filtering was performed to limit our set to single NOAA number HARP regions within $\pm 75°$ longitude. With HARP separated data sets for training and testing our model we implemented a Convolutional Neural Network for the binary classification of flare events with GOES X-ray flare class above C1. We present our initial results of applying the data to the CNN and highlight some of the problems we encountered in the data preparation.

Primary author: JOL, Paloma (Northumbria Univeristy)

Co-authors: Dr BLOOMFIELD, Shaun (Northumbria Univeristy); Dr REGNIER, Stephane (Northumbria Univeristy)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **43** Type: **Poster**

Global Coronal Plasma Diagnostics Based on Multislit Extreme-ultraviolet Spectroscopy

Full-disk spectroscopic observations of the solar corona are highly desired to forecast solar eruptions and their impact on planets and to uncover the origin of solar wind. In this paper, we introduce a new multislit design (five slits) to obtain extreme-ultraviolet (EUV) spectra simultaneously. The selected spectrometer wavelength range (184–197 Å) contains several bright EUV lines that can be used for spectral diagnostics. The multislit approach offers an unprecedented way to efficiently obtain the global spectral data but the ambiguity from different slits should be resolved. Using a numerical simulation of the global corona, we primarily concentrate on the optimization of the disambiguation process, with the objective of extracting decomposed spectral information of six primary lines. This subsequently facilitates a comprehensive series of plasma diagnostics, including density (Fe XII 195.12/186.89 Å), Doppler velocity (Fe XII 193.51 Å), line width (Fe XII 193.51 Å), and temperature diagnostics (Fe VIII 185.21 Å, Fe X 184.54 Å, Fe XI 188.22 Å, and Fe XII 193.51 Å). We find a good agreement between the forward modeling parameters and the inverted results at the initial eruption stage of a coronal mass ejection, indicating the robustness of the decomposition method and its immense potential for global monitoring of the solar corona.

Primary author: CHAN, Lami (School of Earth and Space Sciences, Peking University, Beijing, People's Republic of China)

Co-authors: TIAN, Hui (Peking University); Mr LIU, Xianyu; Dr TÖRÖK, Tibor; Dr BAI, Xianyong; Dr FENG, Yufei; BANERJEE, Dipankar (Aryabhatta Institute of Observational Sciences)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **44** Type: **Poster**

Spectroflat: A generic spectrum and flat-field calibration library for spectro-polarimetric data

Flat fielding spectro-polarimetric data with one spatial and one spectral dimension is inherently difficult and therefore its potential is often not fully exploited. Flat fielding approaches for spectrographs are rarely described in detail, approaches for polarimeters have not been described at all so far. Moreover, the tools needed to calibrate data of a similar type are usually re-invented per instrument.

We present an instrument independent approach for diffraction-grating-based, long-slit spectrographs combined with temporally modulated polarimetry from high-resolution solar telescopes.
It allows for flat-field calibration data to be obtained during regular flat fielding procedures in the observational configuration of the instrument.
We have created robust python libraries that can be plugged into existing pipelines or used standalone.
The libraries perform a field-dependent many-line smile correction, extract flat field maps for slit and sensor dust features, and can provide wavelength calibration based on selected solar atlases.

After calibration, the photon noise level can be closely attained in Stokes Our method derives in robust and precise spectropolarimetric inversion results.
Our correction works across the full spectral range. The algorithm was tested for different wavelength regimes with emission (EUV range) or absorption (near-UV, VIS, IR range) spectra, on data acquired with ground-based, balloon-borne, and space-based instruments.

Our tools extends flat-field techniques to modern instruments with large imaging sensors, covering many spectral lines simultaneously, and with polarimetric capabilities, where methods described so far are not adequate.
We invite the solar community to use our library in their instrument pipelines and contribute to its joint development.

Primary author: HÖLKEN, Johannes (Max Planck Institut für Sonnensystemforschung)

Co-authors: DOERR, Hans-Peter (Thüringer Landessternwarte, Tautenburg, Germany and Max--Planck-Institut für Sonnensystemforschung (MPS), Göttingen, Germany); FELLER, Alex J. (Max-Planck--Institut für Sonnensystemforschung (MPS), Göttingen, Germany)); Dr IGLESIAS, Francisco (Max Planck Institute for Solar System Research)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **45** Type: **Poster**

Surface Flux Transport Modelling using Physics Informed Neural Networks.

The evolution of the solar magnetic field is the key factor governing space weather drivers. Accurate forecasting of space weather requires precise modelling of the magnetic field's evolution on the solar surface using methods like Surface flux transport (SFT). Conventionally used SFT modelling techniques involve grid-based numerical schemes, making them computationally expensive. In this presentation, we present a novel, mesh-independent machine learning-based approach using Physics-Informed Neural Networks (PINNs) to simulate the temporal evolution of Bipolar Magnetic Regions (BMRs) on the solar photosphere. We compare the PINNs-based model with the state of the art numerical model using the Runge-Kutta Implicit-Explicit (RK-IMEX) scheme for both 1D and 2D SFT equations. We find PINNS to be more accurate with better flux conservation than conventional schemes. We further validate the applicability of PINNs with real data by comparing the magnetic flux results from PINNs with observations from SOHO/MDI. The ability of PINNs to solve advection-diffusion equations make it an efficient and accurate technique to simulate magnetograms. These simulations may serve as input boundary conditions for space weather forecasting tools to predict solar wind plasma parameters at the L1 point.

Primary author: Mr J ATHALATHIL, Jithu (Department of Astronomy Astrophysics and Space Engineering, Indian Institute of Technology Indore)

Co-authors: Dr VAIDYA, Bhargav (Department of Astronomy, Astrophysics and Space Engineering, Indian Institute of Technology Indore, India); Dr KUNDU, Sayan (Department of Physics, University of Bath); Dr UPENDRAN, Vishal (Bay Area Environmental Research Institute, Moffet Field, CA, USA., Lockheed Martin Solar and Astrophysics Laboratory, Palo Alto, CA, USA.); Dr C. M. CHEUNG, Mark (CSIRO, Space & Astronomy, PO Box 76, Epping, NSW 1710, Australia)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **47** Type: **Poster**

Bridging the gap between ab initio MHD modelling and avalanche models of solar flares

Solar flares have long puzzled physicists due to their complex and multiscale nature and significant impact on Earth. The prediction of solar flares is challenging because the underlying physical processes are not yet fully understood and cannot yet be observationally resolved. Recent advances have been made using powerful numerical tools such as magnetohydrodynamic (MHD) simulations, though these models are still too computationally prohibitive for real-time prediction. Alternatively, less computationally intensive models, such as avalanche models, have shown promise for real-time solar flare prediction by effectively reproducing solar statistics, such as the distribution of events described by power-laws. However, these cellular automata models suffer from ambiguous physical interpretations.
To bridge the gap between MHD simulations, avalanche models, and real-time forecasting, we investigate the conditions under which cutting-edge MHD simulations can replicate the power-law statistics observed in both the sun and avalanche models. We assess these conditions for simple twisted flaring loops with the PLUTO code and in realistic simulations of the turbulent chromosphere and corona with the Bifrost code. Additionally, we evaluate the validity of the assumptions inherent in avalanche models by verifying if these assumptions are coherent with energy release patterns observed in MHD simulations. Our study aims to provide a solid physical foundation for avalanche models using MHD simulations, thereby providing a robust simplified model for flares that can be used in a variety of applications, such as meteo forecasting, generating synthetic data or studying active regions.

Primary author: LAMARRE, Henri (Université de Montréal)

Co-authors: Dr STRUGAREK, Antoine (CEA Paris-Saclay); Prof. CHARBONNEAU, Paul (Université de Montréal); NORAZ, Quentin (Département d'Astrophysique/AIM, CEA/IRFU, CNRS/INSU, Univ. Paris-Saclay & Univ. de Paris, 91191 Gif-sur-Yvette, France)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **51** Type: **Poster**

Direct Estimates of the Wilson Depression with Stereoscopic Observations of SO/PHI and SDO/HMI

We present a method for a direct measurement of the height variations in the solar photosphere based on stereoscopy. Our method calculates differences in altitude of the solar surface by shifting and correlating two images, mapped from the same surface feature observed from two different vantage points. We apply this method to simultaneous continuum intensity observations from Solar Orbiter's Polarimetric and Helioseismic Imager (SO/PHI) and Solar Dynamic Observatory' s Helioseismic Magnetic Imager (SDO/HMI) to estimate the Wilson depression of sunspots. We present a description of the calibration and rectification of the observational data and an overview of the correlation method. This stereoscopic method allows for the first time to directly compute height variations on the solar surface. We present the results of the analysis, which yield a Wilson depression of roughly 800 km for the observed sunspot. Finally, we discuss the effect that different parameters, especially the resolution of the data have on the results; and the possible extension of this method's applications.

Primary authors: ROMERO AVILA, Amanda (Max Planck Institute for Solar System Research); Dr INHESTER, Bernd (Max Planck Institute for Solar System Research); Dr HIRZBERGER, Johann (Max Planck Institute for Solar System Research); Prof. SOLANKI, Sami K. (Max Planck Institute for Solar System Research)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **52** Type: **Poster**

A multi-wavelength investigation into the photospheric effects of a solar flare on 1 July 2012 using Swedish Solar Telescope observations

The solar flare event of 1 July 2012 13:08 UTC was observed in both the Hα 6563 Å and Fe I 6302 Å lines by the CRisp Imaging SpectroPolarimeter (CRISP) instrument at the Swedish 1-m Solar Telescope (SST), providing information about the connectivity and dynamics of the photosphere, chromosphere and corona. This study focuses on the changes in the sheared photospheric flow pre and post flare. Two pores and several bright points inside the flow pattern in the photosphere are tracked using the Local Correlation Tracking software package YAFTA. The border between two counter flows and the location of a polarity inversion line are identified, while the distance between two pores over time is monitored for the changes in properties of the magnetic field such as polarity, field strength and magnetic energy. The velocity flow vectors show the degree of shearing before and after the solar flare and the Poynting flux quantifies the magnetic energy evolution before and after the flare ribbon formation in the chromosphere. The SST results are combined with results from the Solar Dynamics Observatory (SDO), the Geostationary Orbital Environmental Satellite (GOES) and the FERMI Gamma-Ray Space Telescope providing a multi-wavelength evolution of this event in coronal plasma. The results indicate that the flare is driven by sudden changes in the magnetic field forced in the flows of the photosphere, resulting in the coupling of mass and energy between the layers.

Primary author: Dr STEYN, Ruhann (North-West University, Centre for Space Research)

Co-authors: SCULLION, Eamon (Northumbria University); BOTHA, Gert (Northumbria University)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **61** Type: **Poster**

Fast Downflows Observed during a Polar Crown Filament Eruption

Solar filaments can undergo eruptions and result in the formation of coronal mass ejections (CMEs), which could significantly impact planetary space environments. Observations of eruptions involving polar crown filaments, situated in the polar regions of the Sun, are limited due to their remarkable stability. In this study, we report a polar crown filament eruption, characterized by fast downflows below the filament. The downflows appear instantly after the onset of the filament eruption and persist for approximately 2 hours, exhibiting plane-of-sky (POS) velocities ranging between 92 and 144 km/s. They originate from the leading edge of the filament and no prominent acceleration is observed. Intriguingly, these downflows appear at two distinct sites, symmetrically positioned at the outer sides of the opposite ends of the conjugate flare ribbons. Based on the observations, we propose that the filament might be supported by a magnetic flux rope (MFR), and these downflows possibly occur along the legs of the MFR. The downflows likely result from continuous reconnections between the MFR and the overlying magnetic field structures. We also observed horizontal drifting of the locations of downflows, which might correspond to the MFR's footpoint drifting. This type of downflows can potentially be utilized to track the footpoints of MFRs during eruptions.

Primary author: SUN, Zheng (Peking University)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **63** Type: **Poster**

Localising QPPs in HXR, microwave and Lya emissions of an X6.4 flare

We report the simultaneous observations of quasi-periodic pulsations (QPPs) in wavelengths of hard X-ray (HXR), microwave, Lyα, and ultraviolet (UV) emissions during the impulsive phase of an X6.4 flare on 2024 February 22 (SOL2024-02-22T22:08). The X6.4 flare shows three repetitive and successive pulsations in HXR and microwave wavebands, and they have an extremely-large modulation depth. The onset of flare QPPs is almost simultaneous with the start of magnetic cancellation between positive and negative fields. The wavelet power spectra suggest the presence of double periods, which are centered at $\sim$200 s and $\sim$95 s, respectively. The long-period QPP can also be detected in Lyα and UV wavebands at the flare area, and it could be observed in the adjacent sunspot. Our observations indicate that the flare QPPs are most likely triggered by accelerated electrons that are associated with periodic magnetic reconnections. The long period at $\sim$200 s is probably modulated by the slow magnetoacoustic wave originating from the neighboring sunspot, while the short period at $\sim$95 s could be regarded as its second harmonic mode.

Primary author: LI, Dong (PMO)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **65** Type: **Poster**

Kink-and-Disconnection Failed Eruption in 3D

We report the first stereoscopic observations of HXR emission sources registered by STIX onboard Solar Orbiter and HXI on ASO-S. This is a case study of a two-stage failed eruption. First, it was slowed down due to a helical kink. However, the legs of the kinked structure started to reconnect and the second stage of eruption started. This eruption failed a 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 the reconnection sites and the magnetic cloud confined by overlying fields. Combining stereoscopic X-ray observations from STIX and HXI (31.5 degrees vantage point separation) with Differential Emission Measure (DEM) maps based on SDO/AIA observations we were able to locate X-ray source sites in the corona in the 3D space. The unveiled real geometry allowed us to estimate de-projected values of velocity and acceleration/deceleration which are extremely high. Moreover, real locations of HXR sources are not fully consistent with a standard solar flare scenario.

Primary author: MROZEK, Tomasz (Space Research Centre Polish Academy of Sciences)

Co-authors: Dr LI, Zhentong (Purple Mountain Observatory, Chinese Academy of Sciences); Prof. KARLICKÝ, Marian (Astronomical Institute ASCR); Dr CHRYSAPHI, Nicolina (Sorbonne Université, École Polytechnique, Institut Polytechnique de Paris, CNRS, Laboratoire de Physique des Plasmas (LPP)); Prof. SU, Yang (Purple Mountain Observatory, Chinese Academy of Sciences); Dr CHEN, Wei (Purple Mountain Observatory, Chinese Academy of Sciences); Prof. GAN, Weiqun (Purple Mountain Observatory, Chinese Academy of Sciences)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **69** Type: **Poster**

Investigating the effect of thermal collisional plasma and turbulent acceleration in a simulated coronal acceleration region on heliospheric electron spectra

Non-thermal particle acceleration in the solar corona is evident from both remote hard X-ray (HXR) sources in the chromosphere and direct in-situ detection in the heliosphere. Correlation of spectral indices between remote and in-situ energy spectra presents the possibility of a common source acceleration region within the corona, however the properties and location of this region are not well constrained. To investigate this we perform a parameter study for both the properties of the ambient plasma of a simulated acceleration region and the turbulent acceleration profile acting on an initially isotropic thermal electron population. These electrons are propagated out to 1.0 AU with their energy spectra compared between extremes of the tested parameters. We present results of this parameter search and discuss the relative sensitivity of spectral indices across the heliosphere subject to variation in individual plasma properties and turbulent acceleration profiles consistent with a hot, over-dense source region in the lower corona. We also discuss the suitability of the heliospheric spectral index in constraining the properties of an acceleration region and compare the simulated in-situ energy spectra to that of a simulated chromospheric HXR spectra produced with the same properties.

Primary author: PALLISTER, Ross (Northumbria University)

Co-authors: STORES, Morgan (Northumbria University); JEFFREY, Natasha (Northumbria University)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **73** Type: **Poster**

Forward and MHD modeling of nanojets driven by magnetic reconnection during MHD avalanches

Magnetic reconnection is a leading candidate for the heating of the non-flaring solar corona. Specifically, heating might stem from numerous, localized and impulsive episodes of magnetic energy release. Though potentially intense, those fleeting "Nanoflares"are generally difficult to observe in the corona as the highly efficient thermal conduction and the low emission measure wash out their signatures. The newly discovered phenomenon of fast and swift "Nanojets" has been taken as a direct observational signature of magnetic reconnection as it overcomes the general difficulties in observing nanoflares.

We performed full 3D MHD simulations of interacting and twisted coronal loop strands. In our model the magnetized atmosphere is stratified from the high-beta chromosphere to the corona through the narrow transition region. Photospheric rotation motions stress the flux tubes until they become kink-unstable and determine an avalanche of reconnection episodes. Misaligned magnetic field lines rupture and reconnect, inducing the formation, fragmentation, and dissipation of current sheets akin to a nanoflare storm.
In this work we address the nanojets which develop from these reconnection episodes, at Parker energies (about 1e24 erg) and typical speeds of few 100 km/s, and we investigate their possible detection, in particular in the EUV band with the Atmospheric Image Assembly (AIA/SDO) and the opportunities that spectra and images from the forthcoming MUltislit Solar Explorer (MUSE) will open up. We also perform a statistical analysis of their occurrence and of their correlation with relevant physical ambient parameters, such as the magnetic field, to constrain the best conditions for detection.

Primary author: Mr COZZO, Gabriele (Università degli Studi di Palermo)

Co-authors: Prof. HOOD, Alan W. (University of St Andrews); Dr DE PONTIEU, Bart (Lockheed Martin Solar & Astrophysics Laboratory); Prof. REALE, Fabio (Università degli Studi di Palermo); Dr REID, Jack (University of St Andrews); Dr MARTINEZ-SYKORA, Juan (Lockheed Martin Solar & Astrophysics Laboratory); Dr TESTA, Paola (Harvard–Smithsonian Center for Astrophysics); Prof. PAGANO, Paolo (Università degli Studi di Palermo); Dr HANSTEEN, Viggo (Lockheed Martin Solar & Astrophysics Laboratory)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **76** Type: **Poster**

Horseshoe CME model in EUHFORIA for geo-effectiveness predictions

Coronal mass ejections (CMEs) are giant expulsions of magnetized plasma from the Sun that manifest flux rope structures. Flux rope CME models such as the spheromak model with spherical geometry and the 'Flux Rope in 3D'(FRi3D) model with a global twisted magnetic flux tube geometry are already widely used in studying CME evolution and propagation in the heliosphere within the EUropean Heliosphere FORecasting Information Asset (EUHFORIA). Although the more realistic flux rope geometry of FRi3D is a significant upgrade over the spheromak model, its complex geometrical transformations are a drawback for fast and stable simulations. In this study, we discuss an optimal setup with a geometry more realistic than the spherical plasma blob while the simulations fast and robust enough for operational forecasting setup. This 'Horseshoe'CME model, based on the modified Miller-Turner topology, has been implemented in EUHFORIA and is a modification of the full torus model introduced by Linan et al. (2024). The geometrical implementation of the Horseshoe model is missing the back part of the torus which makes it a more realistic flux rope structure with two legs. In this work, we highlight the methods towards the numerical stability of CME leg disconnection. To make the simulations realistic, we constrain its geometric and magnetic field parameters from observations. We also present the validation of the Horseshoe model with observed CME events and demonstrate how different methods of constraining magnetic field parameters like flux and twist affect the space weather predictions at Earth.

Primary authors: MAHARANA, Anwesha (Centre for mathematical Plasma Astrophysics, KU Leuven); Dr LINAN, Luis (KU Leuven, Belgium); Prof. POEDTS, Stefaan (KU Leuven); MAGDALENIC, Jasmina (Royal Observatory of Belgium)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **77** Type: **Poster**

White-light Emission in the F-CHROMA Grid

Context. Much of a solar flare's energy is thought to be released in the continuum. The optical continuum ("white-light") is of special interest due to the ability of observing it from the ground.
Aims. We aim to investigate the prevalence of white-light emissions in solar flares, what influences them, and what causes them to begin with. We furthermore seek to understand the response of the atmosphere to a flare.
Methods. We utilize the F-CHROMA grid of flare simulations created using the radiative hydrodynamics code RADYN. We probe the spectral index, total energy and low-energy cutoff to draw conclusions about their relationships to white-light emissions. Furthermore, we calculate the 4170 Å continuum emissions, the Balmer and Paschen ratio. Finally, we analyse two particular cases.
Results. 13 of the 83 flares included in the F-CHROMA grid show white-light emissions relative to the pre-flare level that exceed 0.5%. The total energy (or maximum beam flux) seems to be the main factor for deciding whether white-light emissions will be detectable. There is a linear relationship between the Balmer/Paschen ratio and the relative continuum enhancement. Both case studies show the creation of multiple blobs (both hot and cool), as well as H-ionization and subsequent recombination as the most likely reason for Balmer/Paschen continuum emissions.
Conclusions. The parameters of an electron beam impacting the solar atmosphere play a big role in determining several characteristics, such as the white-light emissions and Balmer ratio. White-light emission in the Balmer/Paschen continuum likely result from optically thin hydrogen recombination radiation.

Primary author: Mr ORNIG, Sascha (Rosseland Centre for Solar Physics, University of Oslo, Norway)

Co-author: CARLSSON, Mats (Rosseland Centre for Solar Physics, University of Oslo, Norway)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **78** Type: **Poster**

Inference of atomic line parameters from quiet-sun observations at 1.56 microns

Many spectral lines used for solar observations have poorly determined atomic parameters, such as the transition probability or the central wavelength. Using poor atomic line parameters in spectropolarimetric inversions produces erroneous results for inferred atmospheric parameters. Therefore, we applied a newly developed coupled inversion method to infer the transition probability and wavelength of lines at 1.56 μm from quiet-sun disc-center spectropolarimetric observations taken with the GRIS instrument mounted at the 1.5-meter GREGOR solar telescope. The coupled inversion method relies on the self-consistent inference of the atmospheric and atomic parameters by imposing a spatial coupling in the latter. The retrieved line parameters agree well with previous determinations, in which line parameters were allowed to vary between pixels. However, these modest differences in the atomic line parameters show measurable offsets in atmospheric parameters, mainly in the temperature and line of sight velocity. The retrieved atomic parameters are contrasted against different node placements of the atmospheric parameters. We also considered the variation in the retrieved atomic parameters by inverting different patches from the observed field of view to test the robustness of the coupled method.

Primary author: VUKADINOVIC, Dusan

Co-authors: Dr KORPI-LAGG, Andreas (Max Planck Institute for Solar System Research); SOLANKI, Sami (Max Planck Institut for Solar System Research); NARAYANAMURTHY, Smitha (Max Planck Institute for Solar System Research)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **81** Type: **Poster**

Spectral diagnostics of the solar corona

In most cases, the best spectral diagnostics to measure electron densities / temperatures, chemical composition and non-equilibrium effects in coronal plasma have not been explored at all or only partially (with e.g. little spatial/temporal information).
A few examples, from the X-rays to the infrared are provided, with suggestions for future instruments.

New EUV diagnostics for the outer corona, related to resonance photoexcitation effects are presented, together with new programs and atomic data made available to the community via CHIANTI-VIP, a new member of the CHIANTI family.

New atomic data, line identifications and models for X-ray satellite lines of Fe XVII are also presented. They appear to resolve long-standing problems in some of the strongest X-ray lines. A few problems were known but others were only recently highlighted by the first solar X-ray spectral imaging obtained by the MaGIXS sounding rocket, which indicated a factor of two missing flux around the resonance line.

Primary author: DEL ZANNA, Giulio (University of Cambridge (UK))

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **84** Type: **Poster**

On the detection of solar flares in a Sun-as-a-star setting

Sun-as-a-star (SAAS) observations provide a valuable link between resolved solar observations and disk-integrated stellar observations, as it gives a unique insight into how well-defined solar activity affects the average spectrum. This activity can affect the integrated spectrum in complex ways, and therefore the values of for example reference spectra and exoplanet characterizations. It is therefore important to understand the magnitude and timescale of these variations. We aim to contribute to this field by focusing on the most rapidly changing type of activity: solar flares. We present the first SAAS detection of solar flares with TNG/HARPS, and discuss its effects on the integrated spectrum. When combined with observations made with SST/CRISP&CHROMIS and SDO/AIA, we are able to point to several evolutionary features of the flares in the HARPS data, as well as discuss their imprints on activity indices and RV measurements. Additionally, we expand this work by converting several other SST flare observations into simulated SAAS observations using the Numerical-Sun-as-a-Star Integrator (NESSI). This allows us to show the wide range of spectral imprints that flares can leave on the integrated spectrum based on their morphology, location, and size.

Primary author: PIETROW, Alex (Leibnitz Institute for astrophysics)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **87** Type: **Poster**

Forecasting the propagation and evolution of CMEs using the space weather simulation chain: COCONUT + EUHFORIA

EUHFORIA is a space weather forecasting tool used to predict the geo-effectiveness of coronal mass ejection (CME) impacts. In this 3D MHD simulation, magnetic structures evolve in the heliosphere after being injected into the domain at 0.1 AU. The accuracy of EUHFORIA's predictions strongly depends on the coronal model used to initiate the solar wind and the properties of the CME model inserted to model real events. However, by inserting the CME at 0.1 AU, EUHFORIA does not account for the interaction of the CME with the solar wind near the corona.

These interactions, crucial for accurately assessing the magnetic and thermodynamic properties of the CME, can be studied using another simulation—a global MHD coronal model named COCONUT. COCONUT can track the evolution of flux rope models from the solar surface to 0.1 AU within a realistic description of the solar wind derived from observed magnetograms.

I will present how COCONUT can be coupled with EUHFORIA to dynamically track the propagation of a CME from the Sun to Earth. For this purpose, the outer boundary of COCONUT serves as the inner boundary for EUHFORIA. We tested the coupling through a series of joint runs. In all runs, the magnetic structure of the CME model used in COCONUT (either the Titov-Démoulin flux rope model or the RBSL model) successfully transfers from the coronal to the heliospheric model. The same applies to plasma properties. For example, the sheath that formed in COCONUT ahead of the CME continues to develop in EUHFORIA.

Primary author: LINAN, Luis (KU Leuven)

Co-authors: BARATASHVILI, Tinatin (KU Leuven); Prof. POEDTS, Stefaan (KU Leuven); Dr LANI, Andrea (KU Leuven); SCHMIEDER, Brigitte (Observatoire de Paris); BRCHNELOVA, Michaela (KU Leuven); Dr GUO, Jinhan (KU Leuven)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **88** Type: **Poster**

Fast Magnetic Reconnection Excites a Global Blast Wave in the Solar Corona

Magnetic reconnection is the key mechanism for various explosive phenomena in astrophysical plasmas, such as jets, flares, and coronal mass ejections (CMEs), yet many details remain elusive. An important piece of the puzzle is whether shock waves, a major particle accelerator in the universe, can be excited directly through flaring reconnections rather than driven by the jet/CME piston. Here, by investigating an isolated episode of fast magnetic reconnection leading up to a global blast wave, we give a definite answer. The reconnection occurs at the apex of a magnetic flux rope (MFR) when it rises obliquely from a behind-the-limb active region toward a coronal streamer visible to the Earth; the MFR disappears with its flux being shed by the reconnection. Both the angle of a V-pattern extending outward from the reconnection site and the MFR's speed relative to the background Alfv$e$n speed indicate a reconnection rate as fast as 0.2. The driven nature of the reconnection is manifested in the velocity profile of the MFR emulating the lightcurves of the impulsive hard X-ray (HXR) and microwave emission. An extreme-ultraviolet front expands centering on the reconnection site immediately after the HXR peak. The shock wave nature of the front is unambiguous as it propagates through a prominence embedded in the streamer, producing a γ-ray burst and a metric type II burst. These observations reveal that magnetic reconnection directs a significant fraction of magnetic free energy into exciting the blast wave, comparable to the energy into accelerating electrons.

Primary author: Mr LUO, Runbin (University of Science and Technology of China)

Co-author: LIU, Rui

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **89** Type: **Poster**

Observations of photospheric signatures for pre-eruptive coronal structures

The buildup of the pre-eruptive coronal structure and the eruption onset mechanism are the two most critical yet poorly understood problems. Coronal structures like sigmoids and filaments have been identified as pre-eruptive structures; their associated pre-flare motions as well as pre-flare brightenings have been identified as precursor signatures, yet none of these definitively leads to eruptions, and the cause and effect is always questionable. Most importantly, the associated photospheric magnetic field dynamics are elusive. Here we report the development of pre-flare ribbons of electric currents associated with the buildup of a pre-eruptive structure observed as a bundle of hot low-lying coronal loops collectively taking a sigmoidal shape. Two ribbons of strong vertical electric currents at two sides of the major polarity inversion line (PIL) of the host active region are observed several hours ahead of the appearance of the pre-eruptive structure. More impressively, the buildup of the pre-eruptive structure in the corona is simultaneous with the gradual extension of current ribbons in the photosphere. It is reminiscent of the current-carrying magnetic flux rope (MFR). Continuous brightening were observed along the MFR in the corona when the extension of current ribbon ended in the photosphere, implying the onset of magnetic reconnection. The brightening lasted for 4 hours until the MFR erupted. Quantitative measurements indicate that the MFR's feet, which were well identified by conjugate dimmings occurred during the eruption, possess significant non-neutralized current. Our observations provide a new definitive photospheric signature for the buildup of pre-eruptive structures and imminent eruptions.

Primary author: WANG, Wensi (University of Science and Technology of China)

Co-authors: Prof. LIU, Rui (University of Science and Technology of China); QIU, Jiong (Montana State University)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **90** Type: **Poster**

The Rapid Filament Restructuring in AR 12975 on 28 March 2022 and its Connection to the Subsequent Eruption

We analyzed a rapid filament restructuring during a confined C2 flare that led to an eruptive M4 flare 1.5 h later. During the C2 flare, the filament's southern half disappeared, and the remaining plasma flowed into a new, longer channel, similar to an EUV hot channel seen during the flare.

We took advantage of the quasi-quadrature position (84°) between SDO and Solar Orbiter, during its first science perihelion, by combining close-up (0.33 AU) and side-on observations from the Solar Orbiter/STIX and EUI instruments with on-disk observations from SDO/AIA and HMI, along with nonlinear force-free field extrapolations.

Our results suggest that loop-loop reconnection occurred in an essentially vertical current sheet at a polarity inversion line below the breakup region and involved field lines surrounding the filament channel. This scenario is supported by concentrated currents and free magnetic energy built up by antiparallel flows. It can explain the extended flare loop arcade, the EUV hot channel, and the filament restructuring as the reconnection progressed to involve the filament itself.

In addition, it provides a general mechanism for the formation of the long filament channel via tether cutting, which was active throughout the filament's continuous rise phase, beginning at least 30 min before the C2 flare and continuing until the eruption. These results demonstrate how rapid changes in a filament's topology can be driven by a confined flare due to loop-loop reconnection (Type I confined flare), and how this can contribute to a prolonged tether-cutting process leading to a full eruption.

Primary author: Mr PURKHART, Stefan

Co-authors: VERONIG, Astrid (University of Graz); KLIEM, Bernhard (University of Potsdam); JAROLIM, Robert (University of Graz and High Altitude Observatory, Boulder); DISSAUER, Karin (NorthWest Research Associates, Boulder CO, USA); DICKSON, Ewan (University of Graz); Dr PODLADCHIKOVA, Tatiana (Skolkovo Institute of Science and Technology); KRUCKER, Sam (FHNW School of Engineering and Space Sciences Laboratory, Berkeley)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **94** Type: **Poster**

Potential Predictions of Magnetic Flux Rope Eruptions

Magnetic flux rope eruptions are one of the primary mechanisms behind large coronal mass ejections. Flux ropes are twisted bundles of magnetic flux in the lower solar corona, which can store vast amounts of magnetic energy and remain in quasi-equilibrium for some time. If the conditions are correct, these ropes can violently erupt –but it is also equally possible for them to diffuse away into insignificance. The mechanisms behind such instabilities have been studied extensively for decades, but any definitive method of predicting the timing or magnitude of future eruptions has so far eluded us. In a slightly unusual approach, we have attempted to determine several scalar quantities measured from the magnetic field which could theoretically be used to predict an imminent eruption. With a large parameter study in 2.5D, we have used both MHD and magnetofrictional models to study thousands of flux rope eruptions, and in these simple cases we have found several such diagnostics which can predict imminent eruptions with up to around 90% certainty, providing the magnetic field is accurately reconstructed. We then consider the potential extension of this approach to full 3D models, and the possibilities of combining it with real-time photospheric magnetogram data to theoretically make useful predictions of eruptions and (by extension) potentially problematic space weather events.

Primary author: RICE, Oliver (Durham University)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **95** Type: **Poster**

Chromospheric Fe I lines in the NUV solar spectrum

The near-ultraviolet (NUV) part of the solar spectrum contains a dense haze of spectral lines. Some of the Fe I lines in this region show very broad profiles typical of chromospheric lines which contrast the well-studied photospheric Fe I lines in the visible part of the spectrum. The diagnostic potential of these spectral lines is largely unexplored due to a lack of high-resolution observations. With the SUNRISE III balloon-borne observatory we may for the first time have full spectropolarimetric data at high spatial resolution of this region, and ground-based observatories can also observe the broad Fe I lines around 400 nm. The goal of this work is to investigate and discuss the formation properties of the spectral lines and their suitability for interpreting observations. First, an initial investigation into the formation of a selection of lines was conducted in the FAL one-dimensional semi-empirical solar atmosphere models using the non-LTE radiative transfer code RH. In agreement with earlier works on the Fe I spectrum, we find that the lines are largely affected by over-ionization in the wings, and by scattering in the line cores. The line cores form well into the chromosphere in the tested atmosphere models except the colder FALX model where the line cores form in the temperature minimum. The next step is to investigate the formation of these lines in the dynamic atmosphere of a 3D radiation-MHD model, made with the chromospheric extension of MURaM, and preliminary results from this will be presented.

Primary author: HARNES, Edvarda (Max Planck Institute for Solar System Research (MPS))

Co-authors: Dr NARAYANAMURTHY, Smitha (Max Planck Institute for Solar System Research (MPS)); Dr KORPI-LAGG, Andreas (Max Planck Institute for Solar System Research (MPS)); Dr PRZYBYLSKI, Damien (Max Planck Institute for Solar System Research (MPS)); Prof. SOLANKI, Sami K. (Max Planck Institute for Solar System Research (MPS))

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **97** Type: **Poster**

Locating sites of magnetic energy release in the 2022-10-02 X-class flare

Solar flares are driven by the release of free magnetic energy and are often associated with restructurization of the magnetic field topology. Observations of the evolving magnetic field in the flaring volume are limited to only one case, the X8.2 limb flare on 2017-09-10, where a coherent decay of the magnetic field in the corona was detected cospatial with efficient particle acceleration site at a cusp region. It remains unclear if this phenomenon is typical or exceptional. Here, we report another strong solar flare observed on the solar disk, whose microwave data permit mapping the magnetic field over the flaring source and tracking the magnetic field evolution over the course of the flare. This is done by model spectral fitting of the microwave imaging spectroscopy data obtained with NJIT's Expanded Owens Valley Array (EOVSA). The EOVSA images employed in this study were synthesized with overlapping 4 s time intervals and 2 s cadence at many frequencies between 2.5 and 18 GHz during the rise, peak, and early decay phases of the flare. The plasma parameters derived from this fitting display magnetic field decay in the loop top with the decay rate up to 10 G/s and in other locations.

Primary author: KALTMAN, Tatiana (Institut für Sonnenphysik (KIS), Schöneckstrasse 6, D-79104 Freiburg, Germany)

Co-authors: Dr FLEISHMAN, Gregory D. (Institut für Sonnenphysik (KIS), Center For Solar-Terrestrial Research, New Jersey Institute of Technology); Dr YU, Sijie (Center For Solar-Terrestrial Research, New Jersey Institute of Technology)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **98** Type: **Poster**

Jacobian-Free Newton-Krylov method for multilevel NLTE radiative transfer problems

The calculation of the emerging radiation from a model atmosphere requires knowledge of the emissivity and absorption
coefficients, which are proportional to the atomic level population densities of the levels involved in each transition. Due to the
intricate interdependency of the radiation field and the physical state of the atoms, iterative methods are required in order to calculate
the atomic level population densities. A variety of different methods have been proposed to solve this problem, which is known as the
Non-Local Thermodynamical Equilibrium (NLTE) problem.

In this study we have developed a Jacobian-Free Newton-Krylov method (JFNK) to solve multilevel NLTE radiative transfer problems. Using the Rybicki & Hummer (1992) method as a reference, our results show that our JFNK solver can achieve up to a factor two speed up when using local approximate operators / preconditioner, while also achieving a lower residual error in the statistical equilibrium equations. Another advantage of this method is that the addition of charge conservation and partial redistribution effects should be straight forward.

Our method can help accelerating the calculation of the emerging spectra from numerical models and also the reconstruction of chromospheric datasets through NLTE inversions.

Primary author: ARRAMY, Dimitri (Institute for Solar Physics - Department of Astronomy - Stockholm University)

Co-authors: DE LA CRUZ RODRIGUEZ, Jaime (Institute for Solar Physics, Stockholm University); LEENAARTS, Jorrit

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **99** Type: **Poster**

Monitoring of the solar atmosphere through radio imaging in the 18-100 GHz band: recent results and future challenges

In the frame of single-dish radio monitoring of the solar atmosphere with INAF radio telescopes we are developing and exploiting innovative single-dish radio imaging techniques at high-frequencies up to 100 GHz. Since 2018, we have been monitoring the solar atmosphere in the 18-26 GHz frequency range providing weekly images, in perspective covering the entire current solar cycle (SunDish project). We present an overview of the early scientific results and scientific challenges also in view of the new instrumentation available up to 100 GHz.
In particular, a new solar imaging system at high frequency was recently approved as a permanent observatory in Antarctica (Solaris project). It combines the implementation of dedicated and interchangeable high-frequency receivers on existing small single-dish radio telescope systems (2.6m class) available in our laboratories, on the Alps and in polar regions. Operations in Antarctica will offer unique observing conditions (very low sky opacity and long Solar exposures for nearly 20h/day) and unprecedented Solar monitoring in radio W-band (70-120 GHz). This opens for the continuous monitoring of the chromosphere and the identification and spectral analysis of Active Regions before, after and during the occurrence of Solar flares.
The Solaris observatory will be the only Solar facility offering continuous monitoring at 100 GHz, and it will be able to collect and disseminate data in synergy with the existing national and international network of Space Weather facilities.

Primary authors: PELLIZZONI, Alberto Paolo (Istituto Nazionale di Astrofisica (INAF)); Dr MARONGIU, Marco (Istituto Nazionale di Astrofisica (INAF)); MULAS, Sara (Istituto Nazionale di Astrofisica (INAF)); RIGHINI, Simona (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **100** Type: **Poster**

Simulating fast on-the-fly scans of the solar disk with the Atacama Large Aperture Submillimeter Telescope (AtLAST)

The Atacama Large Aperture Submillimeter Telescope (AtLAST), a proposed 50m single-dish millimetre telescope, could lead to new discoveries in the field of solar millimetre astronomy. With AtLAST's proposed frequency range from ~30 GHz to 1 THz, it would observe the solar continuum radiation originating in the chromosphere. However, the chromosphere's highly dynamic nature prohibits meaningful observations to have long integration and scan times, which could be remedied by utilising fast on the-fly scanning techniques. Such techniques are already used by facilities such as the Atacama Large Millimeter/submillimeter Array (ALMA), completing a scan of the full solar disk in ~ 10 minutes. A sufficiently large multi-pixel detector at AtLAST could reduce the required scan time considerably, ideally to second time scales. By utilising the maria code, a powerful general-purpose telescope simulator, we thoroughly explore how different instrumental properties, scanning strategies and detector counts affect the full-disk observations. A technically feasible multi-chroic instrument was simulated, with properties in line with current expectations for a 1st generation instrument. Such an instrument would allow for instantaneous coverage of large regions on the Sun, even at the higher frequencies considered. Because of the large instantaneously covered region, it is found to be possible to also scan the full disk on very short time scales, on second time scales for an instrument going up to 700 GHz. This would allow us to monitor the active chromosphere on a global scale at an unprecedentedly high cadence, going beyond the capabilities of current facilities in the (sub-)millimetre regime.

Primary author: KIRKAUNE, Mats (Rosseland Centre for Solar Physics, University of Oslo)

Co-authors: Dr WEDEMEYER, Sven (Rosseland Centre for Solar Physics, University of Oslo, Norway); Dr MROCZKOWSKI, Tony (European Southern Observatory (ESO)); Mr VAN MARREWIJK, Joshiwa (European Southern Observatory (ESO))

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **106** Type: **Poster**

Key Roles of External and Internal Reconnection in Small-Scale Solar Events

Small-scale solar events, such as microflares and mini-filament eruptions, are prevalent in the solar atmosphere. However, their eruption mechanisms are still not understood thoroughly. With a combination of 174 Å images of high spatio-temporal resolution taken by the Extreme Ultraviolet Imager on board Solar Orbiter and images of the Atmospheric Imaging Assembly on board Solar Dynamics Observatory, we investigate in detail an erupting mini-filament over a weak magnetic field region. The eruption exhibited two separating bright ribbons and small-scale blobs of 1–2 Mm, suggesting a sequence of internal followed by external reconnection, which transfers magnetic flux to the ambient corona. Additionally, magnetohydrodynamic simulations reveal that magnetic reconnection plays a crucial role in heating localized chromospheric plasma to coronal temperatures, leading to microflares. The magnetic topology analysis discloses that the reconnection region is located near quasi-separators where both current density and squashing factors are maximal with the specific topology varying from a tether-cutting to fan-spine-like structure. High-resolution magnetograms from the Polarimetric and Helioseismic Imager support MHD simulations suggesting that external reconnection generates jets and transfers mass and magnetic twist to the corona. These findings highlight the critical roles of internal and external reconnection in driving small-scale solar events. External reconnection, in particular, transfers mass to the corona, potentially contributing to the solar wind.

Primary author: LI, Zhuofei (Max Planck Institute for Solar System Research)

Co-authors: PETER, Hardi (Max Planck Institute for Solar System Research, Göttingen, Germany); CHENG, Xin (Nanjing University)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **109** Type: **Poster**

A Strong-flare Prediction Model Developed Using a Machine-learning Algorithm Based on the Video Data Sets of the Solar Magnetic Field of Active Regions

It is well accepted that the physical properties obtained from the solar magnetic field observations of active regions (ARs) are related to solar eruptions. These properties consist of temporal features that might reflect the evolution process of ARs, and spatial features that might reflect the graphic properties of ARs. In this study, we generated video data sets with timescales of 1 day and image data sets of the SHARP radial magnetic field of the ARs from 2010 May to 2020 December. For the ARs that evolved from "quiet" to "active" and erupted the first strong flares in 4 days, we extract and investigate both the temporal and spatial features of ARs from videos, aiming to capture the evolution properties of their magnetic field structures during their transition process from "quiet" (non–strong flaring) to "active" (strong flaring). We then conduct a comparative analysis of the model performance by video input and single-image input, as well as of the effect of the model performance variation with the prediction window up to 3 days. We find that for those ARs that erupted the first strong flares in 4 days, the temporal features that reflect their evolution from "quiet" to "active" before the first strong flares can be recognized and extracted from the video data sets by our network. These features turn out to be important predictors that can effectively improve strong-flare prediction, especially by reducing the false alarms in a nearly 2 day prediction window.

Primary author: WANG, Jingjing

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **110** Type: **Poster**

Waves reflection linked with FIP bias

The chemical properties of the solar plasma remain unchanged as it travels unadulterated along open fields from the chromosphere/corona into the heliosphere and can be used as a tracer for the sources of the solar wind.
The solar corona should have the same chemical composition as the solar photosphere. However, It has been found that in the corona, some solar regions exhibit a different chemical composition compared to the lower atmosphere, known as the FIP effect.
For the first time, using spectropolarimetric data from the chromosphere we were able to detect wave reflection, linked with a strong coronal FIP bias, as predicted by the theory.
Unveiling solar wave characteristics from polarimetric measurements still represents a challenge. This detection has been accomplished using phase lag analysis on ground-based chromospheric Stokes V parameters. Using the same theoretical model proposed in 2004 and modified over these 20 years, we found good agreement with the observed results.

Primary author: MURABITO, Mariarita (Istituto Nazionale di Astrofisica (INAF))

Co-authors: LONG, David M. (School of Physical Sciences, Dublin City University, Glasnevin Campus, Dublin D09V209, Ireland); BAKER, Deborah (UCL/MSSL); STANGALINI, Marco (ASI Agenzia Spaziale Italiana); LAMING, Martin J (NRL)

Session Classification: Coffee break and poster session 2

Track Classification: Energy and mass transfer throughout the solar atmosphere and structures within

Contribution ID: **111** Type: **Poster**

Solar Orbiter: Science highlights and mission status

This contribution will review recent science highlights of the ESA/NASA Solar Orbiter mission, with a focus on high-resolution observations of the mission's remote-sensing instruments. Solar Orbiter's science return is significantly enhanced by coordinated observations with other space missions, including Parker Solar Probe, SDO, SOHO, STEREO, Hinode and IRIS, as well as new ground-based telescopes like DKIST. This talk with present examples of such collaborative efforts as well as outline future opportunities. Starting in February 2025, Solar Orbiter's highly elliptical orbit will get progressively more inclined to the ecliptic plane, which will enable the first detailed observations of the Sun's unexplored polar regions. In addition to summarising the observing plans for the first half of 2025, I will describe opportunities for involvement of the entire science community

Primary author: MÜLLER, Daniel (ESA)

Co-authors: Dr WALSH, Andrew (ESA); Dr DE GROOF, Anik (ESA/ESAC); Dr WILLIAMS, David (ESA); Dr JANVIER, Miho (ESA); ZOUGANELIS, Yannis (European Space Agency)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **114** Type: **Poster**

Satellite Orbital Decay and Solar Wind Interactions: A Data Driven Case Study of May 2024 Space Weather Events

In May 2024, a G5-class geomagnetic storm, the most intense since the Halloween solar storms of 2003, hit Earth. Over a dozen X-class flares were observed by GOES, and several Coronal Mass Ejections were launched towards Earth. These events caused significant disturbances in the Earth' s upper atmosphere, impacting satellite orbits and causing auroras to be visible at mid-latitudes globally. Our goal is to assess the critical impact of Space Weather on the decay of Earth-orbiting satellites at different altitudes.

We make use of semi-major axis data from a precise orbit determination method and publicly available two-line-element data, to which we apply a robust time series decomposition method iteratively to remove the most significant periodicity in the data. We compute the orbital decay using this processed data, given the absence of accelerometer data, and analyze the correlation between orbital decay and solar wind parameters, solar activity proxies, and geomagnetic indices, accounting for the solar wind propagation time to the orbits.

For the first half of May, we observe a 15-hour delay between solar wind measurements and their effect on the orbits, and strong associations between orbital decay and several parameters. Consequently, we model orbital decay as a function of solar wind inputs and identify flow speed, electric field, proton densities, and magnetic field strength in the Z direction as the most impactful features. Despite challenges posed by satellite maneuvers and varying wind propagation times, we hypothesize that combining real-time orbital decay with these parameters could facilitate predicting its evolution.

Primary author: MERCEA, Vanessa (University of Bern)

Co-authors: KLEINT, Lucia (University of Bern); Dr ARNOLD, Daniel (University of Bern); Prof. JÄGGI, Adrian (University of Bern)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **115** Type: **Poster**

Modeling of non-radially propagating CMEs and forecasting their arrival time at Earth

We present the study of several halo CMEs that propagated non-radially and as a result, they impacted Earth as flank-encounters. We utilized the default-setup of EUHFORIA and the Cone model for the CMEs, in order to model the selected events. For the modeling input parameters we used a) the DONKI database and b) the GCS technique (Thernisien et. al 2006, 2009) for reconstructing the CMEs. Our study aims to better understand the importance of the direction of propagation in the input parameters of the Cone model and improve the modeled arrival time at Earth. We selected events that had strong non-radial velocity components so that we could see how important are the effects of the low coronal CME deflections for the final direction of propagation and the forecasting of the CME arrival at Earth.
Our results show that, when we use the input parameters from the GCS fitting, up to the height of 12 Solar radii, the modeled arrival time is very close to the observed one, with their difference being up to around 2 hours. On the contrary, when the DONKI data are used, the modeled arrival time is much further (≥10h) from the observed one. This is because at the height of the GCS fittings, the CMEs have experienced all the low corona deflections and they have taken their final direction of propagation.
We used two other methods, the type II radio bursts and the 2D-speed obtained from the coronagraph white light images to compare our modeling results.

Primary author: VALENTINO, Angelos (Centre for Mathematical Plasma Astrophysics, KU Leuven, Leuven, Belgium)

Co-author: Prof. MAGDALENIC, Jasmina (KU Leuven)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **118** Type: **Poster**

On the Origin of the sudden Heliospheric Open Magnetic Flux Enhancement during the 2014 Pole Reversal

Coronal holes are known to be the main source of open magnetic flux (OMF) in the heliosphere. However, there's a notable difference between OMF measured in-situ and the flux estimated from solar observations. This study looks at OMF changes and their link to solar coronal holes and active regions, focusing on a significant OMF increase in September-October 2014.
Firstly, we establish a correlation between the noteworthy OMF increase and the modeled magnetic field on the Sun utilizing the Potential Field Source Surface (PFSS) model. Additionally, we invcestigate the correlation between the OMF and the open flux derived from solar coronal holes and while the OMF evolution is linked to the evolution of the coronal hole open flux, there is no significant correlation with the evolution of the coronal hole area. Furthermore, the temporal increase in OMF aligns well with the disappearance of the residual magnetic field at the southern pole, which resulted from poleward flux circulations induced by the decay of multiple active regions in the southern hemisphere several months earlier.
Additionally, the OMF jump coincided with the emergence of the largest active region of solar cycle 24 in October 2014. This study provides insights into this sudden rise in OMF during this period, enhancing our understanding of Sun-Earth dynamics and helping with space weather prediction and magnetospheric research.

Primary author: HEINEMANN, Stephan G. (University of Helsinki, Finland)

Co-authors: SCOLINI, Camilla (University of New Hampshire); Dr HENNEY, Carl (Air Force Research Laboratory, USA); Dr ARGE, Charles N. (NASA Goddard Space Flight Center, USA); Dr DOWNS, Cooper (Predictive Science Inc., USA); ASVESTARI, Eleanna (University of Helsinki); Dr TURTLE, James A. (Predictive Science Inc., USA); POMOELL, Jens (University of Helsinki); Dr LINKER, Jon A. (Predictive Science Inc., USA); TEMMER, Manuela (Institute of Physics); MADJARSKA-THEISSEN, Maria (Max-Planck Institute for Solar System Research); Dr OWENS, Mathew J. (University of Reading, UK); Dr CAPLAN, Ronald (Predictive Science Inc., USA); PINTO, Rui (LDE3, DAp/AIM/CEA, U. Paris-Saclay); HOFMEISTER, Stefan (stefan.hofmeister@columbia.edu)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **124** Type: **Poster**

The September 5, 2022, coronal mass ejection characterized by remote observations, numerical simulations, and in situ measurements

Open problems in solar and heliospheric physics are (i) how charged particles are accelerated up to high energies and (ii) how they are transported in the inner heliosphere. Among candidates for particle acceleration there are shocks driven by coronal mass ejections (CMEs). We started a new research project (*) whose main methods are remote observations, numerical simulations, and in situ measurements. Here, we show the results of applying these approaches to the fast CME event of September 5, 2022, which was measured in situ by Parker Solar Probe (PSP) and Solar Orbiter, and observed remotely by Stereo-A, SOHO and PSP.

We carry out the reconstruction of the CME by using SOHO/LASCO, STEREO-A/COR2, and PSP/WISPR data. The obtained CME parameters are used as an input for the RIMAP simulation, which also uses the in-situ solar wind data to describe more accurately the initial interplanetary conditions. Then we analyze the in-situ Solar Orbiter measurements to check the results of the RIMAP simulation and to study the CME-driven shock properties, the level of magnetic turbulence around the shock and energetic particle acceleration due to the shock. As preliminary results, we find that the energetic particles differential flux at Solar Orbiter has a spectral index harder than that predicted by diffusive shock acceleration for the measured compression ratio. The possible reasons for such a discrepancy are discussed.

(*) Project "Heliospheric shocks and space weather: from multispacecraft observations to numerical modeling", funded by the Italian MUR within Next Generation EU.

Primary author: Prof. ZIMBARDO, Gaetano (University of Calabria, Rende, Italy and INAF, Italy)

Co-authors: Dr BEMPORAD, Alessandro (Istituto Nazionale di Astrofisica (INAF)); REALE, Fabio (Istituto Nazionale di Astrofisica (INAF)); REALE, Fabio (Università degli Studi di Palermo); FRASSATI, Federica (Istituto Nazionale di Astrofisica (INAF)); Dr NISTICÒ, Giuseppe (Università della Calabria); Dr PRETE, Giuseppe (Università della Calabria); PAGANO, Paolo (Università degli Studi di Palermo); PAGANO, Paolo (Istituto Nazionale di Astrofisica (INAF)); SUSINO, Roberto (Istituto Nazionale di Astrofisica (INAF)); BIONDO, Ruggero (Istituto Nazionale di Astrofisica (INAF)); MANCUSO, Salvatore (Istituto Nazionale di Astrofisica (INAF)); PERRI, Silvia (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **125** Type: **Poster**

First detection of small-scale helical flows in the void of a Coronal Mass Ejection with high-cadence coronagraphic images acquired by the Metis coronagraph on-board Solar Orbiter

On March 26, 2022 the ESA Solar Orbiter mission observed the early evolution of a Coronal Mass Ejection (CME). On that day the spacecraft was at a heliocentric distance of 0.32 AU, and a longitude separation from Earth of 74.5 degrees. The CME source region shows no pre-existing filament or flux-rope. The event was first observed in the inner corona by the EUI telescope, showing the initial propagation of the flux-rope in the EUV. Higher up, the event was observed by Metis with the Visible Light channel with an unprecedented time cadence of 20 sec, and a spatial resolution of 20" corresponding to about 4600 km per bin. The sequence of total brightness images shows for the first time small-scale flows going on inside the expanding flux-rope surrounded by multiple nested arch-shaped features. These plasma motions, not observed by EUI, could be connected with the unknown forces accelerating the eruption. Running difference images built with the cadence offered by previous coronagraphs show the well-known three-part structure of this event, but the real identification of these different classical CME parts is less evident in the high-cadence Metis images. Hence, these observations provide new insight into what is normally identified as the global structure of CMEs.

Primary author: Dr BEMPORAD, Alessandro (Istituto Nazionale di Astrofisica (INAF))

Co-authors: ABBO, Lucia (Istituto Nazionale di Astrofisica (INAF)); ANDRETTA, Vincenzo (Istituto Nazionale di Astrofisica (INAF)); AMATO, Emanuele (Istituto Nazionale di Astrofisica (INAF)); BURTOVOI, Aleksandr (Istituto Nazionale di Astrofisica (INAF)); CAPUANO, Giuseppe Emanuele (Istituto Nazionale di Astrofisica (INAF)); CORSO, Alain Jody (CNR - IFN); DA DEPPO, Vania (Istituto Nazionale di Astrofisica (INAF)); DE LEO, Yara (University of Catania, Max Planck Institute for Solar System Research); FINESCHI, Silvano (Istituto Nazionale di Astrofisica (INAF)); FRASSATI, Federica (Istituto Nazionale di Astrofisica (INAF)); GIARRUSSO, Marina (Istituto Nazionale di Astrofisica (INAF)); GIORDANO, Silvio Matteo (Istituto Nazionale di Astrofisica (INAF)); GUGLIELMINO, Salvatore Luigi (Istituto Nazionale di Astrofisica (INAF)); HEINZEL, Petr (Czech Academy of Sciences); JERSE, Giovanna (Istituto Nazionale di Astrofisica (INAF)); LANDINI, Federico (Istituto Nazionale di Astrofisica (INAF)); NICOLINI, Gianalfredo (Istituto Nazionale di Astrofisica (INAF)); PANCRAZZI, Maurizio (Istituto Nazionale di Astrofisica (INAF)); ROMANO, Paolo (Istituto Nazionale di Astrofisica (INAF)); Prof. ROMOLI, Marco (Università di Firenze); RUSSANO, Giuliana (Istituto Nazionale di Astrofisica (INAF)); SASSO, Clementina (Istituto Nazionale di Astrofisica (INAF)); Dr SPADARO, Daniele (Istituto Nazionale di Astrofisica (INAF)); SUSINO, Roberto (Istituto Nazionale di Astrofisica (INAF)); TERIACA, Luca (Max Planck Institute for Solar System Research, Goettingen, Germany); USLENGHI, Michela (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **127** Type: **Poster**

Observations and Numerical Simulations of the Effects of the Gamma Ray Burst 221009A on the Lower Ionosphere

In this contribution we investigated the impact of a powerful gamma ray burst (GRB) that occurred on October 9 2022, on the Earth's environment using a very low frequency receiver (VLF) to probe the lower ionospheric region (the D region). In addition to the VLF data analysis, we employed numerical simulation through the Long Wavelength Propagation Capability code (LWPC) to derive the increase in the D-region electron density. Our results revealed discernible perturbations in amplitude and phase across all transmitter paths (NAA, DHO, ICV, and NSC) to the Algiers receiver persisting for 40 minutes. At the maximum of the signal perturbation, the LWPC simulation results showed a decrease in the mean new reference height h'from 74 km to 65.71 km, along with an increase in the sharpness factor β from 0.3 km-1 to 0.4875 km-1. Under these new conditions, the electron density increased from its ambient value (216.10 cm-3 to 33.7 103 cm-3

Primary authors: NAIT AMOR, Samir (Center for Research in Astronomy Astrophysics and Geophysics (CRAAG)); Mrs KERRACHE, Fethia; Dr AMMAR, Ahmed (ESPRIT School of Engineering and LSAMA Laboratory, Faculty of Sciences); Dr IKHLEF, Rabah (Center for Research in Astronomy Astrophysics and Geophysics (CRAAG)); Dr DAIFELLAH, Khalil (Center for Research in Astronomy Astrophysics and Geophysics (CRAAG)); Dr BOUYAHIAOUI, Zineddine (Center for Research in Astronomy Astrophysics and Geophysics (CRAAG))

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **129** Type: **Poster**

Mediterranean D-region ionosphere response to solar flares events

Solar flares significantly ionize the neutral atmosphere, leading to increases in the electron density of the ionosphere. This ionospheric disruption impacts the Earth-Ionosphere waveguide, affecting electromagnetic signal propagation between transmitters and receivers. Such ionization-induced perturbations can be observed as fluctuations in the signal amplitude and phase, and thus can be used to estimate the changes in electron density. In this study, we examine the response of the D-region of the lower ionosphere to solar flares by analyzing the Very Low Frequency (VLF) signals emitted by two separate transmitters in the Mediterranean Sea. By combining signal analysis with the Long Wave Propagation Capability (LWPC) code, we simulated the resulting signal perturbation parameters (amplitude and phase) and obtained an increase in electron density. This approach offers insights into the complex interactions between the solar flares and the ionospheric, which is important for communication and navigation systems.

Primary authors: KERRACHE, Fethia (Centre de recherche en Astronomie Astrophysique et Géophysique); Dr NAITAMOR, Samir (Centre de recherche en Astronomie Astrophysique et Géophysique); Dr IKHELEF, Rabah (Centre de recherche en Astronomie Astrophysique et Géophysique)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **130** Type: **Poster**

Magnetic Rayleigh-Taylor instability in Solar Atmosphere: Downward Magnetic Flux Transport

This work dealt with the numerical simulation of the magnetic Rayleigh Taylor instability (IMRT) in a magnetic tube suspended in the chromosphere/photosphere conditions. We solved the compressible nonlinear MHD equations using the 2.5D open-source MPI-AMRVAC numerical code. Therefore we were interested in studying the effect of the horizontal magnetic tension on the development of the IMRT and trying to determine its characteristics. Our results showed that the horizontal magnetic component Bx plays an important role in the development of the IMRT where for higher Bx the number of mushrooms and bubbles decreased and the heat exchange between fluids above the magnetic tube tend to reducing. Moreover, we note that the second horizontal magnetic component Bz we found that this later fellows the displacement of the mushroom toward the photosphere as a frozen field and thus accumulate at the crest of the mushroom. This leads to the increase of the Bz intensity and thus to favorize the buoyancy. As a result of the buoyancy, a coalescence of two mushrooms was observed leading to the formation of a plasmoid with lighter-hot plasma bubbles conditions inside a heavy-colder mushroom and transported toward the photosphere. We also observed that the time variation of the mushroom length contains two phases (slow and fast) and that the time separating the two phases increases when Bx intensity becomes higher. With the process of the IMRT, we were able to explain the rainfall of the prominence plasma material toward the photosphere and reconnection to the surface magnetic field.

Primary authors: Mr BOUABEDELLAH, Ahcene (USTHB); WAFIA, Harhad (Centre de recherche en astronomie atrophysique et géophysique (CRAAG)); Dr NAITAMOR, Samir (Centre de recherche en astronomie atrophysique et géophysique (CRAAG)); Dr ABEDELATIF, Toufik (Centre de recherche en astronomie atrophysique et géophysique (CRAAG))

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **139** Type: **Poster**

Realistic Simulations of Real Active regions

We present a method and application of data-driven simulations with the MURaM radiative MHD code. Combined with a bottom boundary driver that reproduces the evolution of observed magnetic field, the sophisticated energy equation accounts for thermal conduction along magnetic fields, optically-thin radiative loss, and heating of coronal plasma by viscous and resistive dissipation, which allows for a more realistic presentation of observational features of solar active regions and eruptions. To validate the method, the photospheric data from Cheung et al. (2019) are used to drive a series of numerical experiments. The data-driven simulation reproduces the accumulation of free magnetic energy over the course of flux emergence in the ground truth with an error of 3\%. The onset time is approximately 8\,min delayed compared to the ground truth. The data-driven simulation resembles key eruption-related emission features and plasma dynamics of the ground truth flare over a wide temperature. We conduct simulations of eruptive and non-eruptive emerging active regions. The model captures growth of magnetic energy in AR11158 for several days prior to a major flux rope eruption that occurs near the real time of the X2.2 class flare.

Primary author: CHEN, Feng (Nanjing University)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **142** Type: **Poster**

Exploring the variable spectra and magnetic fields of the Active Regions in the chromosphere through high-frequency radio imaging: gyro-resonance emission and flare forecasting

High-frequency radio observations with large single-dish radio telescopes of the INAF network, in the context of the SunDish project, provided ~450 solar images since 2018, useful to monitor the vertical structure and physical conditions of the solar chromosphere both for quiet and active regions, during their evolution at different phases of the solar cycle.
Solar radio mapping in K-band (18-26 GHz) can probe the chromospheric magnetic field of the Active Regions through the detection of gyro-resonance spectral components related to flare events. Enhanced magnetic fields (up 1500-2000 Gauss) determine a spectral flattening ($\alpha<1.5$) in the Active Regions compared to pure free-free emission ($\alpha\sim1.9$) due to the addition of a steeper gyro-resonance component also associated to circular polarization up to ~40%.
When this sporadic anomalous Active Region spectrum is detected, the probability of a strong flare occurrence within 1-2 days is >80%, further rising at >90% also requiring that AR brightness temperature exceeds ~50% the quiet Sun level. We present several examples of 18-26 GHz radio images showing peculiar Active Region spectral and polarization configurations anticipating or following flare events, and through correlation statistics analysis, we discuss the sensitivity and robustness of this flare forecast method and the perspective of coupling it with other multi-messenger Space Weather proxies.

Primary author: Dr MULAS, Sara (Istituto Nazionale di Astrofisica (INAF))

Co-authors: PELLIZZONI, Alberto Paolo (Istituto Nazionale di Astrofisica (INAF)); RIGHINI, Simona (Institute of Radio Astronomy (IRA)); Dr MARONGIU, Marco (Istituto Nazionale di Astrofisica (INAF)); MARCUCCI, Adriana (Aeronautica Militare (Centro Nazionale di Meteorologia e Climatologia Spaziale))

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **144** Type: **Poster**

Mysterious heating source inside an erupting prominence as observed by Solar Orbiter/Metis and ASO-S/SDI instruments

A prominence eruption associated with a limb CME was observed on April 12, 2023 by the multi-channel Metis Coronagraph on board the Solar Orbiter mission. The prominence, seen in the Metis UV Lyman-alpha images as a very bright and elongated arch propagating southward, is instead much weaker in Metis visible light (VL) images. In our work, we studied the 3D position of the prominence to understand the reason for such a significant difference between these two channels. By considering the different processes responsible for the emissions, we obtained the time evolution of the electron density and the temperature of two prominence portions from VL and UV images, respectively. The derived thermodynamic evolution suggests the existence of unknown physical processes providing additional heating source during the plasma expansion. The Lyman-alpha Solar Telescope (LST) on-board the Advanced Space-based Solar Observatory (ASO-S) mission also observed this eruption along the Earth-Sun view. The solar disk imager (SDI) on board the LST observed the prominence lifting from the south-west solar limb, with the south leg fixed onto the Sun as the prominence expand. The SDI Carrington map in Lyman-alpha line was applied to constrain the radiative component of the Lyman-alpha emission.

Primary author: LI, Shuting (Purple Mountain Observatory/INAF-Turin Astrophysics Observatory)

Co-authors: Dr BEMPORAD, Alessandro (Istituto Nazionale di Astrofisica (INAF)); YING, Beili (Purple Mountain Observatory, Chinese Academy of Sciences); FENG, Li

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **149** Type: **Poster**

Statistical study of NUV continuum enhancement in Solar flares

So-called White Light Flares (WLFs) show enhancements in the visible spectrum with respect to the solar black-body curve. The Interface Region Imaging Spectrograph (IRIS) has found enhancements in the NUV spectral region, indicating an enhanced Balmer continuum. Statistical studies using imaging instruments have shown such enhancements to occur commonly, but what causes these enhancements is still a matter of debate, despite significant efforts in the field. It is believed that these enhancements are either a result of the electron beams or of the "backwarming"process, which transfers energy into the lower layers of the solar atmosphere. Although simulations of individual flare events may offer a valuable understanding of particle energy and penetration depth, the examination of numerous flares can provide better constraints and probe the energy transfer process.

We perform a statistical study using IRIS NUV spectral data to classify the occurrence of Balmer continuum enhancements. We use Gaussian process regression (GPR) to detect continuum intensities that are more than 4 sigma above the mean level. These "outliers" are then marked as NUV continuum enhancements. Our findings indicate that most of the enhanced pixels are located on the flare ribbon. Higher energy flares exhibit greater enhancement and a larger enhancement area. Our next step will be to simulate the NUV spectra of flares using the RH code (Uitenbroek 2001) and to provide constraints on the energy transport mechanism for WLFs.

Primary author: SHARMA, Pranjali (University of Bern)

Co-authors: Mr ZBINDEN, Jonas (University of Bern); Prof. KLEINT, Lucia (University of Bern)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **150** Type: **Poster**

Metis Observations of Geoeffective Solar Events

The Metis Coronagraph onboard the Solar Orbiter (SolO) mission is a powerful
instrument capable of observing the solar corona simultaneously in the Visible (VL) broad-band light (580-640 nm) and in the Ultraviolet (UV) narrow spectral range centered on the Lyman α line of Hydrogen at 121.6 nm. This multiwavelength approach allows a comprehensive analysis of various eruptive solar events.

Metis can image the solar corona with very high spatial (down to 4000 km) and temporal resolution(≥ 1s) while at its closest approach to the Sun (i.e at 0.28 AU), the field of view ranges from 1.7 to 3 solar radii. The instrument can measure in that critical region of the corona plasma properties (temperature, energy budget, density distributions, etc.), as well as kinematic states (speed, acceleration, geometry,etc) of solar eruptive events, thus, playing a major role in studying how these form and evolve.

The Metis team is compiling a database of solar eruptive events observed with the Metis Coronagraph. Many of these events may have been geoeffective, i.e. potentially linked to the space weather phenomena. We plan to provide an overview of this subset of the Metis catalogue, highlighting selected geoeffective events.

Primary authors: SASSO, Clementina (Istituto Nazionale di Astrofisica (INAF)); RUSSANO, Giuliana (Istituto Nazionale di Astrofisica (INAF)); Ms SAHANI, Preity Sukla (Istituto Nazionale di Astrofisica (INAF), Capodimonte); GIORDANO, Silvio Matteo (Istituto Nazionale di Astrofisica (INAF)); ANDRETTA, Vincenzo (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **153** Type: **Poster**

Beam-driven evaporation in 2.5D flare simulations with an asymmetric magnetic field configuration

The standard flare model is in generally depicted and studied in 2D simulations with an anti-symmetrical magnetic field configuration, symmetrical in magnitude, either side of the polarity inversion line. However, flare observations confirm that most flare have a significantly asymmetrical values of the magnetic field strength.

Here we present the first multi-dimensional magnetohydrodynamic flare simulation featuring evaporation driven by energetic electron beams in an asymmetrical magnetic field configuration. The simulation conditions that we use are known to rely significantly on those beams of electrons to drive the evaporated plasma upwards from the lower atmosphere (Druett et al. 2023). We study the impact of an asymmetrical configuration on the evolution and geometry of the flare-loop system as well as the impacts on the beam-driven evaporation using the MPI-AMRVAC model.

Primary author: DUBART, Maxime (Center for mathematical Plasma Astrophysics, Department of Mathematics, KU Leuven, Celestijnenlaan 200B, B-3001 Leuven, Belgium)

Co-authors: Dr DRUETT, Malcolm (Center for mathematical Plasma Astrophysics, Department of Mathematics, KU Leuven, Celestijnenlaan 200B, B-3001 Leuven, Belgium); Prof. KEPPENS, Rony (Center for mathematical Plasma Astrophysics, Department of Mathematics, KU Leuven, Celestijnenlaan 200B, B-3001 Leuven, Belgium)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **154** Type: **Poster**

Analysis of solar eruptive events captured by Solar Orbiter during the "Eruption Watch" coordination campaigns.

Solar Orbiter's observations, during Remote Science Windows, a period of ~30 days happening twice per year, are organized into Solar Orbiter Observing Plans (SOOPs). Each SOOP consists of a coordinated set of operations involving multiple instruments to address mission objectives. The Eruption Watch SOOP is a high-resolution plan designed to capture eruptive events, engaging all remote sensing and in-situ instruments.
This presentation focuses on analyzing eruptive events observed during two specific Eruption Watch campaigns in April and October 2023. We have selected events captured by the PHI, EUI, Metis, and SolOHI instruments to study their physical and dynamic properties from the photosphere to the extended corona.
Finally, using observations starting from 2022, we conducted a statistical analysis of the observed erupting events.

Primary author: SASSO, Clementina (Istituto Nazionale di Astrofisica (INAF))

Co-authors: VOURLIDAS, Angelos (Johns Hopkins University - Applied Physics Laboratory); BERGHMANS, David (Royal Observatory of Belgium); OROZCO SUAREZ, David (Instituto de Astrofísica de Andalucía (IAA-CSIC)); LANDINI, Federico (Istituto Nazionale di Astrofisica (INAF)); AUCHÈRE, Frédéric (Institut d'Astrophysique Spatiale); VALORI, Gherardo (MPS); RUSSANO, Giuliana (Istituto Nazionale di Astrofisica (INAF)); STRECKER, Hanna (Instituto de Astrofísica de Andalucía (IAA-CSIC)); HIRZBERGER, Johann (Max-Planck-Institute für Sonnensystemforschung); RODRIGUEZ, Luciano (Royal Observatory of Belgium); HESS, Phillip (U.S. Naval Research Laboratory (NRL), Washington D.C., USA)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **159** Type: **Poster**

A New Method for Finding SEP Event Onset Times and Evaluating Their Uncertainty: Poisson-CUSUM-Bootstrap Hybrid Method

Solar energetic particles (SEPs) are highly energetic charged particles that have their origin of acceleration in strong space-weather driving phenomena that the Sun produces, e.g., solar flares and coronal mass ejections. These particles pose a radiation hazard to both technological equipment and living organisms in space, which is why the nature of these events is an important subject of study in the modern age where space technology is being applied more and more every day.
The onset time of an SEP event at varying energies is a key piece of information in relating the in-situ particle measurements to the remote-sensing observations of solar eruptions. Accurate knowledge of the onset time is an indispensable requirement for identifying the acceleration mechanisms and the source of the energetic particles. What traditional methods lack, however, is the assessment of the uncertainty related to the onset time.
Our method employs a unique combination of a statistical quality control scheme, Poisson-CUSUM, coupled with statistical bootstrapping. By choosing random samples from the background intensity preceding an SEP event and varying the integration time of the data, the method is able to produce a set of distributions of possible onset times. From this set of distributions we extract the most probable onset time and uncertainty intervals relating to this set of distributions.

Primary authors: PALMROOS, Christian (University of Turku); GIESELER, Jan (University of Turku); DRESING, Nina; VAINIO, Rami (University of Turku, Finland)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **161** Type: **Poster**

Slowly Positively Drifting Bursts generated by Large-Scale Magnetic Reconnection

Solar flares are accompanied by many types of radio bursts. In decimetric range the most frequent types are type III and IV (continua) bursts. The slowly positively drifting bursts (SPDBs) we study are rarely observed in decimetric radio emission of solar flares. To understand with what flare process this kind of radio burst is associated and how these bursts can be generated, we studied the radio observations at 800-5000 MHz range together with SDO/AIA imaging observations of the SPDB-rich C8.7 flare on May 10, 2014. (SOL2014-05-10T0702). We detected three groups of SPDBs along with narrow-band type III bursts which temporarily coincided with large-scale magnetic reconnection among the loops of a half dome magnetic configuration found within the active region and a nearby rising sigmoid.

Primary authors: Dr ZEMANOVA, Alena (Astronomical Institute, Czech Academy of Sciences); RYBAK, Jan (Astronomical Institute, Slovak Academy of Sciences, Tatranska Lomnica, Slovakia); KASPAROVA, Jana; DUDÍK, Jaroslav (Astronomical Institute of the Czech Academy of Sciences); KARLICKÝ, Marian (Astronomical Institute ASCR)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **162** Type: **Poster**

Clustering of the Solar Wind at 1 AU: Reconnection and the Ambient Solar Wind

Investigating the solar wind is important for our understanding of the dynamics of plasma in the solar system environment. At 1 AU, where the solar wind interacts with the Earth's magnetosphere, we can also identify different transient processes, such as Interplanetary Coronal Mass Ejections (ICMEs) and Corotating Interaction Regions (CIRs), which may result in the occurrence of magnetic reconnection.
In this work we use Self Organizing Maps (SOMs) 1, an unsupervised learning method which achieves dimensionality reduction via neural networks, to transform the observed time series of WIND spacecraft (proton density, proton temperature, solar wind speed and magnetic field strength) into visual maps. We apply clustering techniques to the resulting maps to obtain a classification of the solar wind. Then, by using a reconnection exhausts catalogue from Eriksson et al. 2022 2 the occurrence of magnetic reconnection in the different clusters is examined.

1 T. Kohonen, 'Self-organized formation of topologically correct feature maps', Biol. Cybern., vol. 43, no. 1, pp. 59–69, Jan. 1982, doi: 10.1007/BF00337288.

2 S. Eriksson et al., 'Characteristics of Multi-scale Current Sheets in the Solar Wind at 1 au Associated with Magnetic Reconnection and the Case for a Heliospheric Current Sheet Avalanche', ApJ, vol. 933, no. 2, p. 181, Jul. 2022, doi: 10.3847/1538-4357/ac73f6.

Primary author: CARELLA, Francesco (KU Leuven)

Co-authors: Dr BEMPORAD, Alessandro; Prof. LAPENTA, Giovanni (KU Leuven); Prof. INNOCENTI, Maria Elena (Institut für Theoretische Physik, Ruhr-Universität Bochum); KÖHNE, Sophia (Institut für Theoretische Physik, Ruhr-Universität Bochum); Prof. ERIKSSON, Stefan (Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **164** Type: **Poster**

Signature of Self-organized Criticality in Flaring Current Sheets

In solar flares, magnetic reconnection is key to restructuring the coronal magnetic fields and converting magnetic free energy into other forms of energies. The footpoints of newly reconnected magnetic flux tubes are mapped by chromospheric flare ribbons. The ribbons hence provide clues for structures of, and reconnection processes in, the coronal current sheet, which are still poorly understood. Here we adopt the UV (1600 Å and 1700 Å) filters of the Atmospheric Imaging Assembly (AIA) on-board the Solar Dynamics Observatory (SDO) to study the detailed evolution of flare ribbons for a sample of 10 two-ribbon flares. We extract flare ribbons based on the variances of AIA 1600/1700 filter ratio. We find that the frequency distribution for waiting times of the identified pixels on the flare ribbons is well described by a power law of index about 1.5, consistent with the theoretical expectation of the self-organized criticality (SOC) model, but the frequency distributions for flaring duration, peak intensity, area under the light curve, and magnetic field strength of the identified pixels generally deviate from power laws as well as from the SOC expectations. These results suggest that time-wise an avalanche process might be ongoing in the flaring current sheet, but in other aspects, e.g., space- and energy-wise, this avalanche is likely modulated by other physical processes.

Primary author: ZHANG, Yue (University of Science and Technology of China)

Co-author: LIU, Rui

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **165** Type: **Poster**

Flare accelerated electrons detected at anchor points of erupting filaments

Stiefel et al. (2023) reported on a first observation in hard X-rays of nonthermal emission coming from the anchor points of an erupting filament. We concluded that flare accelerated electrons must have entered the flux rope and precipitated along the erupting filament into the chromosphere producing Bremsstrahlung in the hard X-ray range.

The detection of such events is challenging for present day instrumentations due to limited dynamical range in imaging hard X-rays. Complementary diagnostics in microwaves are therefore used to search for gyrosynchrotron emission from within the erupting filaments. Here we present joint STIX and EOVSA observations of the SOL2023-12-31 X5-class flare.

Primary author: STIEFEL, Muriel Zoë (Fachhochschule Nordwestschweiz (FHNW) & ETH Zürich)

Co-authors: Mrs COLLIER, Hannah (Fachhochschule Nordwestschweiz (FHNW) & ETH Zürich); Dr KRUCKER, Säm (FHNW & Berkeley); Ms CHEN, Xingyao (NJIT)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **166** Type: **Poster**

Investigating the band-splitting of a type II solar radio burst using LOFAR imaging and spectroscopy

Type II solar radio bursts are regarded as signatures of shock-accelerated electrons in the solar corona. They show emission lanes drifting slowly from higher to lower frequencies at the fundamental and/or harmonic of the local plasma frequency. Occasionally, these lanes can be further split into two components. This phenomenon is known as band-splitting, and its origin is still under debate. In this study, we investigate the band-splitting of a type II radio burst with the Low Frequency Array (LOFAR). The type II burst exhibits a fundamental and a harmonic emission lane. Both lanes are further split into a higher-frequency and a lower-frequency band. The type II burst is associated with a faint CME, and the occurrence of a type II burst and herringbone bursts superimposed on the type II indicate the presence of a coronal shock wave accelerating electrons. Using LOFAR's spectro-polarimetric and imaging observations, we track the locations of the type II radio sources across multiple frequencies. We find two distinct sources: one corresponding to the higher-frequency component and the other corresponding to the lower-frequency component of the split harmonic band. We also find no significant change in the degree of circular polarisation between the two bands. Our results suggest that the components of the split emission lane originate in two close but distinct regions upstream of the shock.

Primary author: Ms NORMO, Sanna (University of Turku)

Co-authors: Dr MOROSAN, Diana (University of Turku); Prof. VAINIO, Rami (University of Turku); Dr ZHANG, Peijin (New Jersey Institute of Technology); Dr ZUCCA, Pietro (ASTRON, the Netherlands Institute for Radio Astronomy)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **170** Type: **Poster**

The Lyman Lines During Solar Flares: Solar Orbiter/SPICE's first high-cadence flare observation

The SPICE instrument on board Solar Orbiter observes in the (extreme-)UV, including the Lyβ and Lyγ lines. Forming in the upper chromosphere, they are very sensitive to energy input and the ionisation stratification, offering important diagnostic information of solar flare energetics. We report here on the first high-cadence (5s) flare observations from SPICE, presenting an overview of the dataset, but focusing our analysis on the Lyman lines. This M-class flare was observed during Solar Orbiter's Major Flare Watch SOOP on 23rd March 2024 ~2348UT. We measure the Lyman decrement (intensity ratio R = Lyβ/Lyγ) as a function of time in an isolated flare footpoint. R decreases impulsively, returning to pre-flare values rapidly, despite the fact that the intensity of each of the Lyman lines (and other EUV spectral lines) returns to pre-flare over a longer duration. In a nearby, weaker, flare ribbon the Lyman decrement shows no meaningful change in response to the flare. A series of field-aligned radiation hydrodynamic simulations were performed, revealing that in electron beam driven flares the synthetic Lyman decrement is very consistent with observations. However, in a flare driven solely by thermal conduction, the Lyman decrement does not exhibit the observed sharp decrease. We conclude that the very strong flare footprint was produced by intense particle precipitation, whereas the weaker conjugate footpoint was more consistent with flare energy transport dominated by thermal conduction. Future analysis will focus on other spectra observed by SPICE, aiming to confirm this picture of differing dominance of energy transport mechanisms.

Primary authors: KERR, Graham (Catholic University of America / NASA GSFC); Dr ALLRED, Joel (NASA GSFC); Prof. KOWALSKI, Adam (CU Boulder / National Solar Observatory); Dr MILLIGAN, Ryan (Queen's University Belfast); Dr BROSIUS, Jeffrey (Catholic University of America / NASA GSFC); INGLIS, Andrew (NASA Goddard Space Flight Center); KRUCKER, Sam (FHNW School of Engineering); Dr KUCERA, Therese (NASA GSFC); Dr PLOWMAN, Joe (Southwest Research Institute); Dr RYAN, Daniel (FNHW); Dr YOUNG, Peter (NASA GSFC)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **172** Type: **Poster**

On the Application of Warm Target Model in Investigating the Time Evolution of Solar Flares

Solar flares are intense localized eruption of electromagnetic radiation over a wide range of energies in the solar atmosphere. A primary characteristics of solar flares is the acceleration of electrons to higher energies and X-Ray observation serves as the key diagnostic to study them in details. In this study, we are investigating the time evolution of solar flares using the warm-target model. This model better constrains the flare parameters, especially the lower energy cut-off of the electron distribution, than the commonly used cold thick-target model. Here, we are using some well-observed flares observed by the RHESSI and the Solar Orbiter (STIX instrument) spacecrafts. Such observations provide us with an excellent opportunity to test the warm-target model in characterizing the time evolution of solar flares. The time evolution of some of the key parameters, e.g., the lower energy cut-off, the total power of non-thermal electrons, the rate of total injected electrons, the excess emission measure from the accelerated electrons in the warm plasma, are very crucial to characterize the acceleration mechanism of electrons in flares. We find an approximate constancy of the lower energy cut-off along the evolution of the flare. Such behaviour also plays a key role in the time evolution of the total non-thermal power of the electrons, and thus in their energy contain. The outcomes of this study, therefore, help us better understand the overall physics of the solar flares.

Primary author: Dr BHATTACHARJEE, Debesh (University of Glasgow)

Co-authors: KONTAR, Eduard (University of Glasgow); Dr LUO, Yingjie (University of Glasgow)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **173** Type: **Poster**

Extreme–ultraviolet transient brightenings in the quiet-Sun corona observed with Solar Orbiter/EUI

The extreme-ultraviolet (EUV) brightenings identified by Solar Orbiter (SolO), commonly known as campfires, are the smallest detected, to date, transient brightenings or bursts observed in the non-active regions of the lower solar corona. Our understanding about the role of campfires in the coronal heating stands elusive due to the absence of extensive statistical studies. We perform statistical analysis of the campfires by using the highest possible resolution observations obtained by the Extreme Ultraviolet Imager (EUI) onboard SolO. We use observations in the 17.4 nm passband of the High Resolution EUV Imager (HRIEUV) of EUI obtained during the closest perihelia of SolO in the year of 2022 and 2023. SolO being at a distance 0.29 AU from the Sun, these observations have exceptionally high pixel resolution of 105 km with the fast cadence of 3 s. We report the detection of smallest campfires in the quiet-Sun. The detected campfires have sizes in the range of 0.01 Mm^2 to 10 Mm^2. Their lifetimes vary between 3 s and 1000 s. Their distribution of size and lifetime shows the power-law behaviour. We estimate that about 10^4 campfires appear per second on the whole Sun. Considering the HRIEUV bandpass that is most sensitive to the 1 MK plasma, the increasingly high number of campfires at smaller spatial and temporal scales over the quiet-Sun regions make them one of the contributors for the quiet-Sun coronal heating.

Primary author: Dr NARANG, Nancy (Royal Observatory of Belgium)

Co-authors: VERBEECK, Cis (Royal Observatory of Belgium); MIERLA, Marilena; BERGHMANS, David (Royal Observatory of Belgium); AUCHÈRE, Frédéric (Institut d'Astrophysique Spatiale)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **174** Type: **Poster**

Reconnection within the erupting flux rope during a solar flare

We present indications of reconnection within the erupting flux rope which occurred during the impulsive phase of the Apr 2, 2022 flare. Combining data from ground-based radiospectrometers, EUV and X-ray data from different vantage points (STEREO, AIA/SDO, EUI/Solar Orbiter, STIX/Solar Orbiter, Fermi), we show that rare and unique radio bursts in the GHz frequency range are co-temporal with specific EUV structures. In addition, the X-ray sources are related to hot EUV loops and footpoints that are all located near or inside the magnetic rope and the erupting filament.

Primary authors: KASPAROVA, Jana; DUDIK, Jaroslav (Astronomical Institute of the Czech Academy of Sciences); KARLICKÝ, Marian (Astronomical Institute ASCR); MASSA, Paolo (Dipartimento di Matematica, Università di Genova); KRUCKER, Sam (FHNW School of Engineering); Dr ZEMANOVA, Alena (Astronomical Institute, Czech Academy of Sciences)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **175** Type: **Poster**

Comparison of Methodologies to Estimate the Tilt Angle in Solar Active Regions

Active regions (ARs) are the photospheric manifestation of the emergence of magnetic flux ropes (FRs) formed within the solar interior. A key parameter of their evolution is the inclination of the AR polarity axis with respect to the equatorial direction, known as the tilt angle, which is fundamental in semi-empirical flux transport models proposed to explain the transference from toroidal to poloidal solar field components. In this work, we review the estimation of the tilt angle in a selection of around 120 bipolar ARs from Solar Cycle 23 using two methodologies. The first method, which is commonly used, computes the magnetic baricenters of the polarities to define the bipole axis. The second method employs an emerging FR model to fit magnetograms of emerging ARs using Bayesian inference. The Bayesian method uses a twisted toroidal FR model to generate synthetic line-of-sight (LOS) magnetograms, which are then compared with actual observations of the evolution of the photospheric LOS magnetic field of emerging ARs. Model optimization is done by sampling the posterior distribution of the parameters with the Markov Chain Monte Carlo technique provided by the PyMC5 library. In previous works, we found that this method corrects for projection effects, such as magnetic tongues, providing a more accurate estimation of the intrinsic inclination of the FRs during the early stages of AR emergence. In this work, we perform a statistical analysis of the tilt dispersions obtained with each method.

Primary author: MANDRINI, Cristina (Instituto de Astronomía y Física del Espacio, IAFE)

Co-authors: Dr POISSON, Mariano (Instituto de Astronomía y Física del Espacio); Dr LÓPEZ FUENTES, Marcelo (Instituto de Astronomía y Física del Espacio); Dr DÉMOULIN, Pascal (Observatoire de París, Meudon, LESIA); Dr GRINGS, Francisco (Instituto de Astronomía y Física del Espacio)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **177** Type: **Poster**

Understanding Precursors of Coronal Mass Ejections and Flares

Coronal mass ejections (CMEs) and solar flares are the most energetic explosive phenomena in our solar system and are able to release a large quantity of plasma and magnetic flux into the interplanetary space, probably affecting the safety of human high-tech activities in the outer space. To predict CME/flares caused space weather effects, we need to elucidate some fundamental but still puzzled questions, one of which concerns how are CME/flares initiated. In this talk, I will first present key observational characteristics before the main phase of CME/flares including the slow-rise precursor and pre-flare activities. I then show a MHD model aiming to understand these disclosed observational characteristics and propose a new CME/flare initiation paradigm.

Primary authors: XING, Chen (Nanjing University); AULANIER, Guillaume (Laboratoire de Physique des Plasmas); DING, Mingde (Nanjing University); CHENG, Xin (Nanjing University)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **179** Type: **Poster**

Solar radio flare observations with the Radio Neutrino Observatory Greenland (RNO-G)

The Radio Neutrino Observatory Greenland (RNO-G) hunts for neutrinos at the highest energies interacting in the deep glacial ice. Seven of its 35 stations (24 antennas/station) have been taking data since 2022. RNO-G is sensitive in the 80-750 MHz region and records snapshots of time-domain waveforms of with GSa/s sampling rate whenever signals above the thermal noise floor trigger a station. RNO-G regularly observes solar flares coincidently with dedicated solar observing radio instruments like Callisto and SWAVES, and with X-class GOES X-ray flares. Data is available in full time- and frequency resolution for all flares. The recorded waveforms show significant impulsivity on O(10's ns) timescales. While these pulses constitute a unique calibration source for the absolute pointing of RNO-G, they also indicate small-scale emission in the sub-structure of radio flares.
In this contribution we highlight the time-domain features seen in the solar flares observed with RNO-G in order to promote the availability and potential usefulness of RNO-G data to the solar physics community.

Primary author: HALLMANN, Steffen (DESY)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **182** Type: **Poster**

EUI onboard Solar Orbiter: unique data for high resolution, far corona and connection science

The Extreme Ultraviolet Imager (EUI) onboard Solar Orbiter is composed of three telescopes, the Full Sun Imager (FSI), and two High Resolution Imagers observing in EUV (HRIEUV) and Lyman-alpha (HRILYA). EUI observes the Sun from the smallest features at the base of the corona and in the chromosphere up to the largest scales in the extended corona.
EUI observations are indispensable for heliospheric connection science as they provide essential information about coronal source regions of eruptive events and solar wind. FSI reveals structure and evolution of the corona to unprecedented distances from the Sun (transients being tracked up to 6 solar radii).
EUI's unparalleled spatial and temporal resolution at perihelion naturally leads to discovery of new structures at previously inaccessible scales such as campfires, picojets, and the smallest decayless kink waves observed to date.
This poster aims to show researchers the way to EUI observations and data analysis. The reader is directed to the latest EUI Data Release, tools and overviews, and kindly invited to become part of the EUI community, facilitated by EUI's open data policy and fast data availability. A particularly effective way to join the EUI community is the Guest Investigator Program of the Royal Observatory of Belgium (ROB), which allows selected researchers to spend a few weeks with the EUI, PROBA2/SWAP or PROBA2/LYRA PI team in Brussels to obtain expert knowledge on the instrument, to participate in observation planning according to the needs of their proposal, and to conduct their research in collaboration with ROB scientists.

Primary author: VERBEECK, Cis (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence)

Co-authors: ZHUKOV, Andrei (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence); NICULA, Bogdan (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence); TALPEANU, Dana-Camelia (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence); BERGHMANS, David (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence); LIM, Daye (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence); D'HUYS, Elke (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence); KRAAIKAMP, Emil (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence); AUCHÈRE, Frédéric (Institut d'Astrophysique Spatiale, France); REID, Hamish (University College London, UK); COLLIER, Hannah (Fachhochschule Nordwestschweiz, Switzerland); LOUMOU, Konstantina (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence); BARCZYNSKI, Krzysztof (PMOD, Switzerland; ETH Zürich, Switzerland); CHITTA, Lakshmi Pradeep (Max Plank Institute for Solar System Research, Germany); HAYES, Laura (ESTEC, The Netherlands); DOLLA, Laurent (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence); HARRA, Louise (PMOD, Switzerland; ETH Zürich, Switzerland); TERIACA, Luca (Max Plank Institute for Solar System Research, Germany); RODRIGUEZ, Luciano (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence); DOMINIQUE, Marie (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence); MIERLA, Marilena (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence); NARANG, Nancy (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence); SMITH, Phil (University College London, UK); AZNAR CUADRADO, Regina (Max Plank Institute for Solar System Research, Germany); PURKHART, Stefan (University of Graz, Austria); MAN-

DAL, Sudip (Max Plank Institute for Solar System Research, Germany); PARENTI, Susanna (Institut d' Astrophysique Spatiale, France); SCHÜHLE, Udo (Max Plank Institute for Solar System Research, Germany)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **183** Type: **Poster**

Coronal dimmings associated with the May 2024 flare/CME events from AR 13664

During the first half of May 2024, Active Region 13664 was the source of 11 X class flares, over 50 M class flares as well as numerous coronal mass ejections (CMEs). The high number of CMEs launched in quick succession caused the largest geomagnetic storm since two decades. The most distinct phenomena in the low corona associated with CMEs and strong flares are coronal dimmings, which are localized regions of transiently reduced emissions observed in extreme ultraviolet (EUV) and soft X-ray (SXR) wavelengths. As such, they are important diagnostics for CME activity (in particular for Earth-directed CMEs) and provide insights on the accompanying physical processes in the low corona. In this contribution, we present a systematic study of the coronal dimmings associated with the flares in AR13664 as observed by the AIA instrument onboard the Solar Dynamics Observatory between the 3rd and 14th of May. We study the dimming parameters (area, brightness, magnetic flux) and relate them with key characteristics of the observed CMEs. We also attempt to understand the magnetic configuration involved in these eruptive events by studying the anchor points of the coronal dimmings and the associated flare ribbons.

Primary author: RAZQUIN LIZARRAGA, Amaia (University of Graz)

Co-authors: VERONIG, Astrid (University of Graz); DISSAUER, Karin (NorthWest Research Associates, Boulder CO, USA); Dr PODLADCHIKOVA, Tatiana (Skolkovo Institute of Science and Technology); SHANTANU, Jain (Skolkovo Institute of Science and Technology); Dr CHIKUNOVA, Galina (Hvar Observatory, University of Zagreb); THALMANN, Julia (University of Graz); DUMBOVIC, Mateja (Hvar Obs.)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **187** Type: **Poster**

Benchmarking Solar Simulations: An Analytical Solution for Non-Linear Diffusivity

Numerical simulations have proven invaluable in understanding the physics of the Sun. With increasing computing power available, we launch increasingly complicated multi-physics simulations. Every single physics module requires validation and we must understand the role of each of these physical processes. This work presents an analytical solution for non-linear diffusivity in 1D, 2D, and 3D. We will use it to benchmark the Spitzer conductivity module in the single and multi-fluid radiative MHD codes Bifrost and Ebysus. The solution is based on the self-similar solutions by Pattle, 1959, which required the diffusing quantity to be zero beyond a finite radius. We have surpassed this constraint, allowing for a small non-zero background value. This problem is highly relevant in the Solar atmosphere, where energy released in nanoflares or originating in the hot MK Corona diffuses to the much colder kK Photosphere. Beyond this use, the derivation and argumentation are general and can be applied to other non-linear diffusion problems.

Primary author: Dr FURUSETH, Sondre Vik (Institutt Teoretisk Astrofysikk, Universitetet i Oslo)

Co-authors: CHERRY, George (Institutt Teoretisk Astrofysikk, Universitetet i Oslo); Dr MARTÍNEZ-SYKORA, Juan (Lockheed Martin Solar and Astrophysics Lab, USA and Insitutt Teoretisk Astrofysikk, Universitetet i Oslo)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **190** Type: **Poster**

Predicting Soft X-ray Emissions for Solar Flare Forecasting Using a Self-Supervised CNN Trained on Solar Dynamics Observatory Data

Predicting solar flares is crucial for communications and satellite operations. Previous Machine Learning (ML) work focused on classifying flares with labels such as M and X, overlooking the continuous nature of X-ray flux. Our approach uses Convolutional Neural Networks (CNNs) to predict X-ray flux from Helioseismic and Magnetic Imager (HMI) and Extreme Ultraviolet (EUV) images of the Sun, using a curated dataset from the Solar Dynamics Observatory (SDO). Inputs represent different layers of the solar atmosphere: HMI magnetograms (photosphere) and AIA wavelengths: 94 Å (flaring regions), 171 Å (quiet sun), 193 Å (coronal structures), and 304 Å (chromosphere). Data are processed to match SDO images and GOES X-ray fluxes. Limb-brightening correction is applied to avoid biases. We compare full-disk images versus synoptic maps as CNN inputs.

We utilise the Model Genesis self-supervised framework, originally developed for medical imaging. It consists of an encoder-decoder architecture to reconstruct artificially deformed solar images by transformations such as non-rigid deformations and pixel shuffling. The encoder part is attached to our CNN and pre-trains it. This process facilitates extracting robust features for better performance. Subsequently, we train to predict X-ray flux. We post-process outputs to associate X-ray flux predictions with flare indices to compare our work with other classifications. We benchmark this approach against state-of-the-art methods using True Skill Score (TSS) for categorical predictions and Brier Skill Score (BSS) for probabilistic predictions. Future work includes eXplainable AI (XAI) to identify which active regions and parts of the solar atmosphere contribute most to flare predictions.

Primary author: Dr GONIDAKIS, Panagiotis (Centre for Plasma Astrophysics (CmPA), Katholieke Universiteit Leuven (KULeuven))

Co-authors: MILOSHEVICH, George (KU Leuven); CARELLA, Francesco (KU Leuven); Dr BEMPORAD, Alessandro (Istituto Nazionale di Astrofisica (INAF)); LAPENTA, Giovanni; Prof. POEDTS, Stefaan (KU Leuven)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **193** Type: **Poster**

Solar Flare Forecasting Utilizing Deep Survival Analysis

Solar flares and accompanying coronal mass ejections are drivers of intense space weather, which can have major impacts on e.g., satellite communication, navigation, and power-grid integrity. To this day, precise predictions of solar flare events remain challenging, due to the complexity of the underlying physical processes.
This study aims to improve solar flare forecasting through the application of survival analysis, a method traditionally used in fields like medicine and economics to model the timing of events and their related data features. In extension to previous studies, we aim to model not only the likelihood of a flare happening within the next few days but also its timing.
We demonstrate the time-to-event prediction capabilities of deep survival neural networks based on multivariate time series extracted from solar photospheric vector magnetograms in Spaceweather HMI Active Region Patch (SHARP) series.
Preliminary results indicate that deep survival analysis provides a promising new avenue for more precise event time predictions of solar flare outbursts. We found that including active regions that produce multiple flares in both training and validation sets, while keeping the flares themselves separated, yields highly accurate predictions with hour-level precision.

Primary author: MEYER ZU WESTRAM, Moritz (Astronomical Institute, University of Bern)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **196** Type: **Poster**

Denoising Helioseismic Far-Side Images with Spatial and Temporal filters

Helioseismology can detect active regions on the Sun's far side days before they rotate to the Earth's side, using solar acoustic oscillations. These far-side maps provide an important input for space weather models. Recent advances in theoretical and computational helioseismology have improved far-side imaging, which enables high-confidence detection and daily tracking of medium-size active regions. However, these images still suffer from substantial noise due to the stochastic nature of the oscillations. In practice, temporal averaging and Gaussian smoothing have been used to reduce the noise level. These approaches indeed improved the signal-to-noise ratio, yet, the duration for temporal averaging and width for Gaussian filters are chosen based on experience, which are far from optimal. Our study aims to denoise these images by implementing spatial and temporal filters in spectral space to mitigate this noise.

Primary author: RAWAT, Aarushi (Max Planck Institute for Solar System Research)

Co-authors: Dr YANG, Dan (Max Planck Institute for Solar System Research); Prof. GIZON, Laurent (Max Planck Institute for Solar System Research)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **200** Type: **Poster**

The use of artificial intelligence techniques in the prediction of the solar activity cycle 25

Predicting future solar activity cycles is a complex task that requires the incorporation of machine learning techniques. The aim of this study is to apply neural network techniques to the prediction of the 25th period of the solar cycle series. We consider two methods for the prediction models, namely the Nonlinear AutoRegressive eXogenous (NARX) and the Voting Regressor (VR) (with combinations). The input data are the observed sunspot numbers (SSN) of the last four cycles. Several models are constructed and their performance is evaluated using the following metrics: Root Mean Square Error (RMSE), Pearson Correlation Coefficient (PCC) and Nash-Sutcliffe Efficiency (NSE) evaluation metrics. The obtained results from the VR algorithm of the solar maximum activity of the 25th cyles is 119.19 < $R_{max,VR}$ < 126.27 which is expected to be in the period between November - December 2024. The evaluation metrics obtained are 3.4 < $RMSE_{VR}$ < 6.7, 0.997 < r_{VR} < 0.998 and 0.972 < NSE_{VR} < 0.994. The results obtained from the NARX algorithm show a maximum value of $R_{max,NARX}$ = 130.84, which is expected in April 2025. The evaluation metrics are $RMSE_{NARX}$ = 7.515, NSE_{NARX} = 0.972 and r_{NARX}= 0.986. The results of these two models are compared with the observations and used to predict the next solar cycles.

Primary author: KALKAN, Mirkan Yusuf

Co-author: Prof. FAWZY, Diaa (Izmir University of Economics)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **203** Type: **Poster**

Deep learning image burst stacking to reconstruct high-resolution ground-based solar observations

To study and resolve small-scale features in the solar atmosphere, ever larger telescopes are built, such as the European Solar Telescope (EST) or the Daniel K. Inouye Solar Telescope (DKIST). However, diffraction-limited observations are not feasible for large aperture telescopes because the Earth's turbulent atmosphere distorts the raw observations. Therefore, post-image reconstruction techniques must be applied to obtain high resolution, high quality observations.
We provide an AI tool based on deep learning which is capable of translating a short exposure image burst to a single high resolution high quality observation. The neural network we use was developed by Jarolim et al. (2023) and is based on a Generative Adversarial Network (GAN) that employs unpaired image-to-image translation. This allows translating a short exposure image burst consisting of 100 images to a single high quality observation in real time. This approach can outperform state-of-the-art methods such as speckle reconstruction and multi-frame blind deconvolution (MFBD).
We applied the tool to observation from the 1.5 m GREGOR telescope. The results demonstrate that our approach provides faster and more robust reconstructions by showing less artifacts compared to the speckle reconstruction method. We explicitly show that our neural network approach uses the information of 100 short exposure observations for the reconstruction.

References:

Jarolim, R., Veronig, A., Pötzi, W. Podladchikova, T. (2023). "Instrument-To-Instrument translation: Instrumental advances drive restoration of solar observation series via deep learning." under revision, Nature Communications DOI: 10.21203/rs.3.rs-1021940/v1

Primary author: SCHIRNINGER, Christoph

Co-authors: Dr JAROLIM, Robert (High Altitude Observatory, Boulder, USA); Prof. VERONIG, Astrid (University of Graz, Kanzelhöhe Observatory for Solar and Environmental Research); Dr KUCKEIN, Christoph (Max-Planck Institute for Solar System Research, Germany)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **207** Type: **Poster**

Ca II K brightness as a function of magnetic field strength and characteristics of the observations

Solar observations have often served as benchmarks of stellar conditions. A particularly illustrative example of the above link is given by the observations in the Ca II H and K lines at 396.847 nm and 393.367 nm, respectively, which are the two deepest and broadest absorption lines in the visible spectrum of the Sun. Although widely observed over the years, several aspects of the emission of these lines are however still not fully understood. This is the case of e.g. the exact relationship between Ca II K emission and magnetic field strength. To the aim of reassessing this relationship, we analysed state-of-the-art observations of the solar atmosphere obtained at the Swedish Solar Telescope with the Crisp Imaging Spectropolarimeter and Chromospheric Imaging Spectrometer instruments on regions characterized by a different ambient magnetic field. On these observations we analyzed the dependence of the Ca II K line brightness on different surrounding conditions of the solar atmosphere and characteristics of the observations, such as spectral bandwidth and spatial scale. The results derived from our study are functional to e.g. high-precision transit photometry applied in exoplanets research, investigation of the solar-stellar connection, and accurate reconstructions of the evolution of the solar magnetism over decadal and centennial time scales.

Primary author: ERMOLLI, Ilaria (Istituto Nazionale di Astrofisica (INAF))

Co-authors: GIORGI, Fabrizio (INAF); ROUPPE VAN DER VOORT, Luc (Rosseland Centre for Solar Physics, University of Oslo); MURABITO, Mariarita (Istituto Nazionale di Astrofisica (INAF)); JAFARZADEH, Shahin (Max Planck Institute for Solar System Research / Niels Bohr International Academy); CHATZISTERGOS, Theodosios (Max Planck institute for solar system research)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **208** Type: **Poster**

Metis Solar Wind Speed Maps during the first half of the 25th solar cycle: the role of the assumed electron temperature radial profile

The derivation of the coronal proton bulk speed is one of the main goals of the Metis coronagraph on board the Solar Orbiter S/C. Metis is capable of acquiring both visible-light (VL) broadband (580-640 nm) polarized brightness (pB) images and ultraviolet (UV) HI Lyman-alpha (121.6 nm) images simultaneously with high temporal (up to 1 s for the UV and 60 s for VL/pB) and spatial (down to 4500 km/pixel) resolution. The proton outflow speed is derived from these data through the Doppler-dimming diagnostics. Here solar wind speed maps are presented that are derived for four Solar Orbiter Remote Sensing Windows. This outlines the evolution of the solar wind during half of the 25th solar cycle (from the end 2021 to the end 2023). Different literature electron temperature profiles are used as a parametric input for the Doppler-dimming diagnostics, thus deriving the sensitivity of the Doppler-dimming diagnostics to the knowledge of the electron temperature profile of the coronal plasma in different regions in the field of view (e.g. streamer, coronal holes). For the first time, a novel dynamical (DYN) model from literature was used to better constrain the electron temperature profile adopted in the Doppler-dimming diagnostics. Preliminary results show the role played by the knowledge of the coronal electron temperature in the derivation of the solar wind maps.

Primary author: FRASCELLA, Francesco (Istituto Nazionale di Astrofisica (INAF))

Co-authors: Dr SPADARO, Daniele (Istituto Nazionale di Astrofisica (INAF)); CAPUANO, Giuseppe Emanuele (Istituto Nazionale di Astrofisica (INAF)); ZANGRILLI, Luca (Istituto Nazionale di Astrofisica (INAF)); Prof. ROMOLI, Marco (Università di Firenze); SUSINO, Roberto (Istituto Nazionale di Astrofisica (INAF)); FINESCHI, Silvano (Istituto Nazionale di Astrofisica (INAF)); GIORDANO, Silvio Matteo (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **210** Type: **Poster**

Magnetic helicity and energy budgets of jet events from an emerging solar active region

Using photospheric vector magnetograms obtained by the Helioseismic and Magnetic Imager on board the Solar Dynamic Observatory (SDO) and a magnetic connectivity-based method, we compute the magnetic helicity and free magnetic energy budgets of a simple bipolar solar active region (AR) during its magnetic flux emergence phase which lasted ∼47 hrs. The AR did not produce any coronal mass ejections or flares with an X-ray class above C1.0 but it was the site of 60 jet events during flux emergence. The helicity and free energy budgets of the AR were below established eruption-related thresholds throughout the interval we studied. However, in addition to their slowly-varying evolution, each of the time profiles of the helicity and free energy budgets showed discrete localized peaks, eight of which occurring at times of jets emanating from the AR. These jets featured larger base areas than other jets triggered in the AR. We estimated, for the first time, the helicities and free magnetic energies associated with the jets; they vary in the ranges $(0.5-7.1)\times10^{40}$ Mx^2 and $(1.1-10.4)\times10^{29}$ erg, respectively. The pertinent percentage changes were significant and ranged from 13% to 76% for the normalized helicity and from 9% to 57% for the normalized free energy. Our study indicates that occasionally jets may play a significant role in the evolution and dynamics of emerging solar active regions by having a significant imprint in the evolution of their helicity and free magnetic energy budgets.

Primary author: NINDOS, Alexander (University of Ioannina, Greece)

Co-authors: Prof. PATSOURAKOS, Spiros (University of Ioannina, Greece); Dr MORAITIS, Kostas (University of Ioannina, Greece); Prof. ARCHONTIS, Vasilis (University of Ioannina, Greece); Dr LIOKATI, Evangelia (University of Ioannina, Greece); Dr GEORGOULIS, Manolis (The Johns Hopkins University Applied Physics Laboratory, USA and Research Center for Astronomy and Applied Mathematics, Academy of Athens, Greece); Dr NORTON, Aimee (Stanford University, USA)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **211** Type: **Poster**

Radiative Magnetohydrodynamic Simulation of the Confined Eruption of a Magnetic Flux Rope: Unveiling the Driving and Constraining Forces

Flares and CMEs are different manifestations of the same energy release process, during which flux ropes act as the key magnetic structure. However, due to the lack of in-situ observation, it is still difficult to capture the dynamic evolution of flux rope in detail. Here, we analyze the forces that control the dynamic evolution of a flux rope in a 3D RMHD simulation conducted with the MURaM code, whose eruption gives rise to a C8.5 confined flare. The flux rope rises slowly with an almost constant velocity of a few km/s in the early stage when the gravity and Lorentz force are nearly counterbalanced. After it rises to the height where the decay index of the external poloidal field satisfies the torus instability criterion, the significantly enhanced Lorentz force breaks the force balance and drives the rapid acceleration of the flux rope. Fast magnetic reconnection is immediately induced within the current sheet under the erupting flux rope, which provides strong positive feedback to the eruption. The eruption is eventually confined due to the tension force from the strong external toroidal field. Our result provides a detailed and comprehensive analysis on the dynamic evolution of flux rope eruption, which suggests that the gravity of plasma plays an important role in sustaining the quasi-static stage of the preeruptive flux rope, while the Lorentz force, which is contributed from both the ideal MHD instability and magnetic reconnection, dominates the evolution of flux rope during the eruption process.

Primary authors: WANG, Can (Nanjing University; Kyoto University); CHEN, Feng (Nanjing University); DING, Mingde (Nanjing University); LU, Zekun (Nanjing University)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **214** Type: **Poster**

Physically-consistent Riemann solvers for accurate and robust MHD modelling with low plasma beta

The solar atmosphere hosts various physical phenomena driven by strong magnetic fields, but accurate and efficient MHD numerical modelling of such phenomena is challenging. Specifically, high accuracy typically requires low numerical dissipation, which may come with high computational costs and is prone to numerical oscillations. Conversely, efficiency demands sufficient robustness, which needs adequate numerical diffusion. These challenges must be addressed adequately in MHD models, such as the newly developed fully-implicit MHD global solar coronal model, COCONUT.

While COCONUT currently uses finite-volume discretisation and approximate Riemann solvers that are well-established for MHD simulations, their robustness is often challenged under strong magnetic fields or, more precisely, in low-beta plasma. One important reason is that magnetic energy becomes dominant compared to the much smaller thermal energy. Thus, even a small numerical discrepancy in magnetic energy may lead to negative thermal energy, causing the positivity-preservation problem, typically tackled by adding numerical diffusion. This issue, of course, also exists in other plasma MHD simulations.

Without adding numerical diffusion, we ensure physical consistency in HLL-type Riemann solvers, specifically the consistency between the numerically calculated magnetic field and magnetic energy, which is frequently broken in numerical solutions. The resulting Riemann solvers are more robust than their widely used counterparts, yet with less diffusive effects observed in fully implicit global coronal modelling. Additionally, we have discussed the positivity-preservation property of the proposed Riemann solvers and explained the reason behind their improved robustness.

Primary author: Dr ZHANG, Fan (University of Oslo)

Co-authors: BRCHNELOVA, Michaela (KU Leuven); LANI, Andrea (KU Leuven); Prof. POEDTS, Stefaan (KU Leuven)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **216** Type: **Poster**

CHIANTI version 11 - advanced ionization equilibrium models: density and charge transfer effects

CHIANTI is the most widely-used database in solar physics, and in some cases is the reference dataset for other databases in astrophysics. We present here a significant update to the modelling. CHIANTI has, up until now, used the coronal approximation to calculate ion balances. This is only suitable in the more tenuous, high temperature solar corona. New effects have been added to the models to make them more appropriate for the solar transition region, where densities are higher and temperatures cooler. This includes density effects on ionisation and recombination rates. Also, charge transfer, which occurs during collisions between atoms and ions, has been included in CHIANTI for the first time. We present an example run of the new models by creating a synthetic spectrum for an active region using differential emission measure modelling. Line intensities are enhanced by factors of 2-5 in certain cases compared to the previous modelling. We compare the results with observations from HRTS and find excellent agreement for transition region lines. The results resolve some long-standing discrepancies in predicting emission for the Si IV lines observed by IRIS, as well as for C IV and N V

Primary authors: DELIPORANIDOU, Evangelia (University of Cambridge); DEL ZANNA, Giulio (University of Cambridge (UK)); DUFRESNE, Roger (University of Cambridge)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **217** Type: **Poster**

Observational discovery of slip-running reconnection during a solar flare

Apparent slipping motions of reconnecting field lines are a prime signature of three-dimensional magnetic reconnection, the process powering flares and eruptions. The existence of slipping motions in the super-Alfvénic regime is a key prediction of 3D magnetohydrodynamic extensions to the standard flare model. Validating these predictions proved challenging as the detection of slipping motions, typically of flare loops and flare kernels, has been limited by the time resolution of space-borne solar imagery. We overcame this issue by utilizing high, 1.8 s cadence flare observations of a confined C4.2-class flare from 2022 September 25 of the Interface Region Imaging Spectrograph (IRIS). Flare ribbon kernels, composing one of the ribbons captured in the 1330 Å filter of the IRIS Slit Jaw Imager, exhibited apparent slipping motions at speeds of thousands of kilometers per second. These dynamics are consistent with the slip-running reconnection, aligning with model predictions. Signatures of kernel motions were further analyzed in observations with varying spatial and temporal resolution. By utilizing a computer vision algorithm we found that fast, super-Alfvénic dynamics can only be resolved in observations with a cadence of a few seconds at most. Preliminary analysis of selected IRIS flare datasets with high (< 2s) time resolution strengthens these results, confirming that the rapid kernel slippage was not limited to a single event.

Primary authors: LORINCIK, Juraj (BAERI/LMSAL); Dr DUDÍK, Jaroslav (Astronomical Institute of the Czech Academy of Sciences)

Co-authors: Dr SAINZ DALDA, Alberto (BAERI/LMSAL); Prof. AULANIER, Guillaume (LPP, Sorbonne Université; RoCS, University of Oslo); Dr POLITO, Vanessa (LMSAL; Department of Physics, Oregon State University); Dr DE PONTIEU, Bart (LMSAL; RoCS, University of Oslo)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **218** Type: **Poster**

Partial eruptions by breakout reconnection

Knowing how much of a particular magnetic system will erupt is, naturally, fundamental to predicting a CME event and the hazard it presents. Usually, we speak about full eruptions when most of the magnetic structure escapes from the Sun, producing a CME; and about failed/confined eruptions, when the eruptive process, including flares and filament activation, is halted in the low corona, with no magnetic structure escaping the Sun. However, there is a continuous transition between both cases, depending on the portion of the stressed magnetic system that is expelled. Commonly, these eruptions are denoted as partial filament eruptions and are the most frequently observed.

In this work we present, for the first time, three events of partial filament eruptions that suffer the splitting after the eruption started and produced a CME, instead of a jet outflow. The events were simultaneously observed by STEREO-A, SDO, and Solar Orbiter. Taking advantage of the multiple viewpoints we track the real three-dimentional evolution of different features and segments of the filament material. We model the background coronal magnetic field, showing an interaction between the filament and multipolar structures. We used the CORHEL-CME model to simulate the event and provide an explanation of the physical process behind this kind of partial eruptions. We conclude that the breakout reconnection within the null point of these structures allows the stressed magnetic system to partially erupt and to reconnect with the background field in order to produce a CME structure.

Primary author: SAHADE, Abril (NASA Goddard Space Flight Center)

Co-author: KARPEN, Judith (NASA Goddard Space Flight Center)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **226** Type: **Poster**

The highest resolution full-disk magnetic field maps, obtained with SO/PHI

The Polarimetric and Helioseismic Imager onboard the Solar Orbiter spacecraft (SO/PHI) has the unique opportunity to scan the entire solar disk within approximately 4 hours with its High Resolution Telescope (HRT). Such a so-called "full-disk mosaic" was produced on March 22, 2023 at a solar distance of 0.495 AU where the SO/PHI-HRT platescale of 0.5" covered a distance of 179.5km on the Sun.

Connecting the 25 tiles of the full-disk mosaic provides a full-disk magnetogram with a solar disk diameter of approximately 8000 pixels. In addition to the line-of-sight magnetogram we will present full disk mosaics of the magnetic field inclination and azimuth, i.e. the entire photospheric magnetic field vector. Beside the magnetic field maps, we will also show mosaics of the Doppler velocity and the continuum intensity in the 617 nm band.

Simultaneously with SO/PHI the Extreme Ultraviolet Imager (EUI) onboard Solar recorded a full-disk mosaic in the 17.4 nm band. A combination of the SO/PHI and EUI observations provide and unique data product with with an unprecedented view of the Sun.

Primary author: HIRZBERGER, Johann (Max-Planck-Institute für Sonnensystemforschung)

Co-authors: Dr CALCHETTI, Daniele (Max-Planck-Institute für Sonnensystemforschung); Dr VALORI, Gherardo (Max-Planck-Institute für Sonnensystemforschung); Dr LI, Xiaohong (Max-Planck--Institute für Sonnensystemforschung); Prof. SOLANKI, Sami K. (Max-Planck-Institute für Sonnensystemforschung); Dr DEL TORO INIESTA, Jose Carlos (Instituto de Astrofísica de Andalucía); Dr OROZCO SUAREZ, David (Instituto de Astrofísica de Andalucía); Dr GANDORFER, Achim (Max--Planck-Institute für Sonnensystemforschung); Dr WOCH, Joachim (Max-Planck-Institute für Sonnensystemforschung); THE SO/PHI TEAM

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **227** Type: **Poster**

The CAESAR project: Comprehensive spAce wEather Studies for the ASPIS prototype Realization

This work presents the outcome of the CAESAR (Comprehensive spAce wEather Studies for the ASPIS prototype Realization) project, which was supported by ASI and INAF from 21 December 2021 to 24 May 2024 (ASI-INAF n.2020-35-HH.0 agreement). CAESAR was devoted to study the relevant aspects of Space Weather (SWE) science and realize the prototype of the scientific data centre for Space Weather of the Italian Space Agency (ASI) called ASPIS (ASI SPace Weather InfraStructure). To this end, CAESAR gathered a great part of the SWE Italian community, bringing together 10 Italian institutions as partners, and a total of 98 researchers.
CAESAR adopted an unprecedented, multidisciplinary, and integrated approach, encompassing the whole chain of phenomena from the Sun to the Earth up to planetary environments.
The goals, organization, and final results are discussed.
A case study of a well-observed "target SWE event", exhibiting extreme characteristics with respect with the solar source, is presented in order to showcase the CAESAR approach. The causes and evolution of the event are explored and the effects on technological systems are evaluated.
The main features of the implemented ASPIS prototype are shown. It is intended to unify multiple SWE resources through a flexible and adaptable architecture and to integrate currently available international SWE assets to foster scientific studies and advance forecasting capabilities.

Primary author: Dr LAURENZA ON BEHALF OF THE CAESAR TEAM, Monica

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **231** Type: **Poster**

Using Data-driven time-dependent Magnetofrictional modeling to initiate Magnetohydrodynamic simulations of coronal active regions

The data-driven time-dependent magnetofrictional method (TMFM) has proven to be a powerful tool for studying solar coronal eruptive events. Coupling data-driven TMFM with magnetohydrodynamic (MHD) simulations potentially provides a robust and efficient approach to study such events in more detail.

As has been shown by a number of studies, TMFM is capable of incorporating observational data directly. Additionally, it is significantly faster to compute compared to MHD, due to the simplifications of the model. The main aim of this work is to utilize the data-driven TMFM, initiated with observational data, close to the time of the expected eruptive event, and transfer the magnetic field evolved with TMFM to initiate an MHD simulation, providing a more realistic initial condition for the MHD simulation. The goal is to leverage the lower computational cost of TMFM while simulating the fast and more dynamic evolution of eruptive events with the more complete MHD model. As an example case for our approach, we simulated NOAA active region 12673, with the linked data-driven TMFM and ideal zero-β MHD simulation. The main twisted flux system in our simulation was rising during the MHD simulation, however, the final height of the flux system depended on how close to eruption the transformation of the model from TMFM to MHD was performed. Our simulations showed the primary factors in the eruptive event are the torus instability and presence of the slip-running reconnection.

Primary authors: DAEI, Farhad (University of Helsinki); POMOELL, Jens (University of Helsinki); PRICE, Daniel (University of Helsinki); Dr KUMARI, Anshu (NASA Goddard Space Flight Center); GOOD, Simon; KILPUA, Emilia (University of Helsinki)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **234** Type: **Poster**

Association between a Failed Prominence Eruption and the Drainage of Mass from Another Prominence

Sympathetic eruptions of solar prominences have been studied for decades, yet identifying their causal relationships remains challenging. Here, we analyze a failed prominence eruption and subsequent mass drainage from a neighboring prominence, and investigate their potential connections. Leveraging stereoscopic observations from instruments such as LST, CHASE, and EUI, we observe that the southern prominence (PRO-S) erupts with untwisting motions, accompanied by flare ribbons, and new connections form during the eruption. Notably, the northern prominence (PRO-N) rises following PRO-S, and its upper section disappears due to catastrophic mass drainage along an elongated structure. We propose that the eruption of PRO-S was initiated by the kink instability and facilitated by flare reconnection. However, it ultimately failed to erupt due to reconnection with surrounding magnetic fields. The elongated structure connecting PRO-N overlies PRO-S, and PRO-N mass drainage is triggered by PRO-S failed eruption. This study highlights that a prominence may terminate its life through catastrophic mass drainage, where the rising motion and mass drainage reinforce each other, and the mass drainage can be initiated by an underlying eruption.

Primary author: XUE, Jianchao (Purple Mountain Observatory)

Co-authors: FENG, Li; Prof. LI, Hui (Purple Mountain Observatory); TEAM, LST; TEAM, CHASE

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **236** Type: **Poster**

Understanding the magnetic field evolution of the 10 March 2022 Coronal Mass Ejection

Understanding the magnetic field evolution of Coronal Mass Ejections (CMEs) is crucial for space weather research. We examined the 10 March 2022 CME, focusing on its magnetic field evolution from the near-Sun space to L1. The Solar Orbiter's in-situ measurements, 7.8 degrees east of the Sun-Earth line at 0.43 AU, provided a unique vantage point, along with the WIND measurements at L1.

We analysed the temporal evolution of the magnetic helicity budget of the source Active Region (AR), NOAA AR 12962. By estimating the helicity budget of the pre- and post-eruption phase in the AR, we estimated the helicity transported to the CME. Assuming a Lundquist flux-rope model and geometrical parameters (length and radius of the flux rope) obtained through the Graduated Cylindrical Shell (GCS) CME forward-modelling technique, we determined the CME magnetic field at a GCS-fitted height of 0.03 AU to be 2067 ± 405 nT.
Combining this estimated magnetic field with in-situ measurements at 0.43 AU and 0.99 AU, we could fit the CME's axial magnetic field decrease with heliocentric distance as a single power law with index -1.23 ± 0.18. Extending previous studies on inner-heliospheric intervals from 0.3 AU to ~1 AU, we refer to estimates from 0.03 AU to measurements at ~1 AU. Our findings suggest a less steep decline in the magnetic field strength with distance compared to previous studies. However, our results align with studies incorporating near-Sun magnetic field measurements, such as those from the Parker Solar Probe mission.

Primary author: KOYA, SHIFANA (University of Ioaninna Greece &UMCS, Poland)

Co-authors: Prof. NINDOS, Alexander (University of Ioaninna Greece); Dr GEORGOULIS, Manolis K (Space Exploration Sector, Johns Hopkins Applied Physics Laboratory, Laurel, MD 20723, USA); Prof. PATSOURAKOS, Spiros (University of Ioaninna Greece)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **237** Type: **Poster**

Soft X-ray Solar Flare Spectroscopy: Synergistic Observations from XSM and STIX

We present a detailed analysis of solar flares observed on 30 September 2022 using high-resolution spectroscopic data from the X-ray Spectrometer (XSM) onboard Chandrayaan-2 and the Spectrometer/Telescope for Imaging X-rays (STIX). By leveraging XSM's broad-band spectral sensitivity and STIX's spectra in the softer energy range, we explore the intricate dynamics of solar flare emissions.

We conducted a comparative study of solar flares, focusing on key spectral features such as line emissions and continua in the soft X-ray band. The synergy between XSM and STIX data enables a comprehensive understanding of flare morphology and evolution.

Key findings include determinations of flare temperatures, emission measures, and elemental abundances, providing valuable insights into theoretical models of physical processes crucial for solar flares.

Primary author: KĘPA, Anna (Space Research Centre Polish Academy of Sciences)

Co-author: SIARKOWSKI, Marek (Space Research Centre Polish Academy of Sciences)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **238** Type: **Poster**

Is the sub-flaring activity of a solar active region a good whistleblower for impending eruption?

Our Sun is a dynamic star, home to a wide range of activities, from subtle, short-duration events to large coronal mass ejections (CMEs) and strong flares. CMEs and flares can overlap; distinguishing between "eruptive"and "confined"flare magnetic configurations is essential. Understanding the intricacies of these solar eruptions and their connections to preceding activity is crucial in heliophysics research. Our goal is to determine whether the small-scale activity of an active region (AR) contains information about its potential for eruptions and could provide insight into future events. To achieve this, we monitor transient activity using data from the Atmospheric Imaging Assembly (AIA) instrument onboard the Solar Dynamics Observatory (SDO). Our primary goal is to discern disparities in AR transient brightenings of various magnitudes and understand their relevance to eruptive configurations. By comparing the spatial distribution of detected transient brightenings to the polarity inversion line (PIL) area derived from the SDO Helioseismic and Magnetic Imager (HMI) line-of-sight magnetograms, we observe significant differences between the pre-eruptive and non-eruptive situations of our sample ARs. The temporal evolution of observations derived from the brightenings, such as their number detected through time, their associated intensity and magnetic unsigned flux, shows significant differences in their order of magnitude and behaviour, and by using multiple wavelengths, we also observe the evolution of the transient activity through the Sun's atmosphere. Over comparative analysis, we seek insights into the pre-eruptive activity of ARs, which could contribute meaningfully to advancing solar event predictive capabilities and our understanding of solar dynamics.

Primary author: ANDRÉ-HOFFMANN, Augustin (University of Ioannina / University of Sheffield)

Co-authors: NINDOS, Alexander (University of Ioannina); Dr GEORGOULIS, Manolis (RCAAM of the Academy of Athens); PATSOURAKOS, SPIROS (University of Ioannina); ERDELYI, robertus (univ of sheffield)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **239** Type: **Poster**

Comparative analysis of the open and closed field topologies reconstructed by different coronal models

When reconstructing the coronal magnetic field topology, which is an essential input to heliospheric space weather forecasting models, one can chose among many coronal models. These range from simple empirical to state-of-the-art magnetohydrodynamic (MHD) models. In this study we try to address how well coronal models agree well with each other regardless of their complexity and simulation set up. In addition, we investigate for each model the sensitivity of the simulation output with respect to variations of the initial set up. We considered four potential field source surface (PFSS)-based models and one full MHD model, all of which were initiated with two different types of HMI ADAPT magnetograms generated for three consecutive dates. One magnetogram included active regions added retrospectively while the other did not. All PFSS based outputs were compared to the one generated by the MHD model. This analysis revealed that all models considered here produce very comparable open and closed field topologies. Taking the work one step further, we selected a coronal hole that was centered within the Earth's field of view, for the three dates studied, and compared its area with the simulated open field topology associated with it. We found that they do not compare well. As a conclusion, despite not agreeing well with observations, simulated topologies from different coronal models agree well with each other.
This work is the result of collective research by members of the International Space Science Institute (ISSI) team "Magnetic Open Flux And Solar Wind Structuring Of Interplanetary Space".

Primary author: ASVESTARI, Eleanna (University of Helsinki)

Co-authors: SCOLINI, Camilla (University of New Hampshire); HENNEY, Carl (Air Force Research Laboratory, USA); ARGE, Charles N. (NASA Goddard Space Flight Center, USA); SAMARA, Evangelia (Royal Observatory of Belgium and KU Leuven); POMOELL, Jens (University of Helsinki); LINKER, Jon A. (Predictive Science Inc., USA); TEMMER, Manuela (Institute of Physics); MADJARSKA-THEISSEN, Maria (Max-Planck Institute for Solar System Research); OWENS, Mathew J. (University of Reading, UK); CAPLAN, Ronald (Predictive Science Inc., USA); PINTO, Rui (LDE3, DAp/AIM/CEA, U. Paris-Saclay); HOFMEISTER, Stefan (stefan.hofmeister@columbia.edu); Dr HEINEMANN, Stephan G. (University of Helsinki, Finland)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **240** Type: **Poster**

Flare Accelerated Electrons in Kappa-Distribution from X-Ray Spectra with Warm-Target Model

Flare-accelerated energetic electrons play a critical role in the magnetic energy release and transport during solar flares. X-ray diagnostics provide crucial insights into the acceleration and propagation of energetic electrons. A deeper understanding of the dynamics of energetic electrons after injection is required to improve the X-ray spectral analysis. Previous studies have shown that the dynamics of accelerated electrons with a few thermal speeds are complex. To address this, a model considering energy diffusion and thermalization effects has been developed to characterize flare-accelerated electrons for hard X-ray spectral analysis. This warm-target model has demonstrated how the low-energy cut-off, which can hardly constrained from the cold-target model, can be determined. However, the power-law form may not be the most suitable
representation of injected electrons. The kappa distribution is proposed as a physical consequence of electron acceleration and has exhibited successful application in RHESSI spectral analysis. In this study, we employ the kappa distribution to represent the injected electrons in the warm-target model to analyze well-observed RHESSI and STIX flares. We find that the kappa-form energetic electrons require lower non-thermal energy to produce a similar photon spectrum compared to the power-law form. Additionally, unlike the power-law distribution with a lower energy cut-off, the kappa distribution extends to the entire energy range. The use of the kappa distribution enables the determination of crucial electron properties such as electron number density and average energy in the flare site, thereby offering further constraints on electron acceleration processes.

Primary author: Dr LUO, Yingjie (University of Glasgow)

Co-authors: Dr BHATTACHARJEE, Debesh (University of Glasgow); KONTAR, Eduard (University of Glasgow)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **241** Type: **Poster**

Observations and modeling of solar flare energetic electrons in hard X-ray, radio and in-situ near 1 AU

The behavior of energetic electrons from solar flares traveling through interplanetary space is crucial for understanding space environment and its impact on Earth. This transport is effectively influenced by the pitch-angle scattering due to the broad existence of interplanetary magnetic turbulence. However, how does the strength of pitch-angle scattering change over the electron energy and other parameters is still to be ascertained. In this work, we present the pitch-angle scattering dependence on the traveling distance and the electron energy. We analyze 14 energetic electron events that are detected in-situ by the Wind 3D Plasma and Energetic Particle instrument and accompanied by coincident hard X-ray (HXR) emission and interplanetary type III radio bursts. These events are with single short-duration electron injection as indicated by HXR light curves, and the injection time is determined from HXR observations. We find that the arrival time of the electrons in energy bands from 27 to 520 keV are delayed for around a thousand seconds with respect to their free-flying time; and find the statistical energy dependence of the rise and decay time of electron flux profiles. We numerically model the transport of electrons considering the pitch-angle scattering and magnetic focusing. By conducting simulation experiments, we obtain the scattering mean free path as well as its dependence on distance from the Sun and the electron energy that best suits the observations.

Primary author: KOU, Yuankun (Nanjing University; University of Glasgow)

Co-author: KONTAR, Eduard (University of Glasgow)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **250** Type: **Poster**

Disentangling coronal hard X-ray emission from the total signal through stereoscopic observations with Solar Orbiter/STIX and FERMI/GBM

In this work we take advantage of the unique orbit of the Solar Orbiter spacecraft which enables us to study flares from multi-viewpoints away from the Sun-Earth line. A dataset of flares for which the chromospheric footpoint emission is occulted from Solar Orbiter's point of view and the total flare emission is observed by Earth based observatories (i.e. Fermi/GBM) are identified. This allows the study of coronal hard X-ray emission separately to the total integrated signal in hard X-ray for a given flare. Coronal emission is typically much fainter and thus often challenging to disentangle from the total integrated flux with current hard X-ray instrumentation, due to the limited dynamic range of indirect imaging techniques. The study of the "above the loop-top"source allows us to probe the physics of what is commonly thought to be the acceleration region in flares and to advance our current understanding of particle acceleration. In this on-going investigation the relative flux of non-thermal emission in the corona versus footpoint emission is quantified. This constraint is important as it provides guidance for the required dynamic range of the next generation of hard X-ray instruments. In addition, the time evolution of coronal and footpoint emission is compared in order to investigate whether the purely coronal source shows the same pulsations as the footpoint sources. This analysis will help us better understand quasi-periodic pulsations in flare emission.

Primary authors: COLLIER, Hannah (Fachhochschule Nordwestschweiz, ETH Zürich); KRUCKER, Säm; HAYES, Laura (European Space Agency)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **252** Type: **Poster**

Development of a solar/stellar wide-spectral coverage polarimeter for investigating flare energetics

The solar/stellar wide-spectral coverage polarimeter, SOWISP, is a dedicated instrument for investigating time-dependent energetics of solar flares. With four-state polarisation measurements and a field-of-view the size of an average sunspot, the instrument, currently in the R&D phase, will allow to probe changes in the magnetic structure with a spatial resolution of below 20 arcsec. Unique among spectropolarimeters is its large spectral range in the visible regime, which includes the Balmer and Paschen continua from 350 nm, as well as lines from the hydrogen Balmer series, up to the chromospheric Ca II 854.2 nm line. Observations of both the continua and line spectra over this range, with a targeted spectral resolving power of 30k at 600 nm, will elucidate the heating and energy conversion mechanisms at different atmospheric heights in flares and allow to discriminate between models.

The spatial and spectral resolution will be achieved through the use of an integral field unit and a primary Echelle disperser, respectively. Designed for portability and through phased deployment, the instrument also lends itself to the study of stellar magnetic field variations, particularly of bright M dwarfs, by utilising our own 80 cm ZimMAIN telescope at our Zimmerwald Observatory, or by bringing SOWISP as a visitor instrument to other telescopes worldwide.

This presentation will describe the science goals, design and ongoing development of SOWISP, with emphasis on its unique and versatile spectropolarimetric capabilities for investigating the underlying mechanisms behind both solar and stellar flares.

Primary author: GALLOWAY, Michelle (University of Bern)

Co-authors: PAILLON, Dorian (University of Bern); KLEINT, Lucia (University of Bern)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **256** Type: **Poster**

Modelling of Coronal Mass Ejections Through the Novel FRi3D Model and the Effect of Twist Parameter

Coronal Mass Ejections (CMEs) are large-scale eruptive events originating from the magnetically complex regions of the Sun, and also the most energetic phenomenon in the heliosphere. Even though CMEs have been largely studied in the last several decades, and despite significant advances in our knowledge about them, a lot remains unknown about their internal structure, dynamics, and how they link to their interplanetary counterparts. Determining CMEs configuration and topology is also important for comprehending the amount of magnetic energy stored in the corona prior to CME eruption. Observations indicate that the energy is stored as a highly sheared and/or twisted magnetic field located above the polarity inversion line (van Ballegooijen et al., 2006). In the present work, we analyse Earth-directed CMEs occurring in 2022, where the availability of data from spacecraft in different viewpoints allows for a comprehensive analysis,insight into their evolution and link with the interplanetary counterpart. For the modelling of the CMEs we used the state-of-the-art 3D magnetohydrodynamic (MHD) heliospheric model EUHFORIA (EUropean Heliospheric FORecasting Information Asset). We coupled EUHFORIA with the novel flux-rope CME model FRi3D (Flux-Rope in 3D), which provides a rather realistic morphology of the CME structure. We study how the variation in the twist parameter impacts the predictability of kinematic and magnetic properties of CMEs when using the FRi3D model.

Primary authors: DORSCH, Brenda (Royal Observatory of Belgium); MAGDALENIC, Jasmina (Royal Observatory of Belgium); RODRIGUEZ, Luciano (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **257** Type: **Poster**

Parameters' Maps Generated by Intensity of the Lyman-beta and Lyman-gamma Lines from SPICE Data and Non-LTE Modeling

An observation of a prominence on the solar limb took place on April 15, 2023, by several instruments including the Spectral Imaging of the Coronal Environment (SPICE) and the Extreme Ultraviolet Imager (EUI) on board Solar Orbiter. We aim to create parameter maps on the prominence region, including temperature, pressure, and column mass, by studying the integrated intensity of the Lyman-beta and Lyman-gamma lines from SPICE data.
After constraining the altitude and radial velocity in this event, we use a 1D non-LTE radiative transfer code to generate 1000 random models and compute the Lyman-beta and Lyman-gamma line profiles. The computed intensities are compared with observed integrated intensities from SPICE. Then, we find models which simultaneously give a reasonable match with the observed intensities in both the two lines. This enables us to generate models from pixels on the prominence region and use this information to generate parameter maps. We will discuss the results obtained and the potential for future research.

Primary authors: Mr ZHANG, Yong (University of Glasgow); Dr LABROSSE, Nicolas (University of Glasgow); Dr PARENTI, Susanna (Université Paris Saclay); Dr KUCERA, Therese (NASA Goddard Space Flight Center)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **258** Type: **Poster**

The ASPIS prototype: the Database, the Web App, and the Python Package

The prototype of the scientific data centre for Space Weather of the Italian Space Agency (ASI) called ASPIS (ASI SPace Weather InfraStructure) has been recently developed and validated by the CAESAR (Comprehensive Space Weather Studies for the ASPIS prototype Realization) project.
The ASPIS prototype unifies multiple Space Weather (SWE) resources (data and models) through a flexible and adaptable architecture to allow scientists to perform studies across the SWE-related fields, e.g., adopting an integrated approach, encompassing the whole chain of phenomena from the Sun to the Earth up to planetary environments or parts of it.
This work presents the solutions adopted for the architecture and the functions defined on the prototype to cope with the challenging requirements of searching heterogeneous datasets, as well as the first results of creating the ASPIS prototype. The database handles the heterogeneity of metadata and data while storing and managing the interconnections of various space weather events. The pilot database is complete, installed at ASI, and accessible through different user interfaces, including a graphical web interface and an advanced Python module called ASPISpy, which have been specifically developed to facilitate data discovery, access, and analysis.

Primary authors: DEL MORO, Dario (Università di Roma Tor Vergata); LAURENZA, Monica (Istituto Nazionale di Astrofisica (INAF))

Co-authors: Dr BIGAZZI, Alberto (Italian Space Agency); MILILLO, Anna (Istituto Nazionale di Astrofisica (INAF)); Dr PLAINAKI, Christina (Italian Space Agency); Dr POLENTA, Gianluca (Italian Space Agency); Dr SINDONI, Giuseppe (Italian Space Agency); Dr GIARDINO, Marco (Italian Space Agency)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **260** Type: **Poster**

Solar wind modelling with EUHFORIA and the PSP observations

The recently available observations of the solar wind by Parker Solar Probe (PSP) at close to the Sun distances show large variations. Majority of attempts to model solar wind with EUHFORIA (European heliospheric forecasting information asset, Pomoell & Poedts, 2018), along the PSP trajectory, provided not very accurate modelling results. In attempt to understand the source of this inaccuracy, we studied the solar wind observed during the first ten perihelion of PSP. Number of intervals of enhanced solar wind velocity appearing simultaneously with the decrease of the solar wind density was found, indicating that this solar wind is originating from the coronal holes. Employing the magnetic connectivity tool (developed by ESA's MADAWG group) we confirmed the sources of that enhanced solar wind to be small coronal holes. In this study we present the characteristics of the solar wind flows originating from such a small coronal holes and compare them with characteristics of the fast solar wind originating from the large coronal holes, at close to the Sun distances. We discuss on the possible reasons for the lack of the fast solar wind in the PSP observations. In addition, we compare the characteristics of solar wind observed at close to the Sun distances and at 1 au.

Primary authors: MAGDALENIC, Jasmina (Royal Observatory of Belgium); VALLIAPPAN, Senthamizh Pavai (Royal Observatory of Belgium)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **266** Type: **Poster**

Hard X-ray Flare observations by Solar Orbiter/STIX

The hard X-ray imaging spectrometer STIX onboard Solar Orbiter has been operating continuously for 3.5 years recording over 50'000 solar flares. This poster will present science highlights including results from the Solar Orbiter Flare Watch from Spring 2024.

Primary author: KRUCKER, Säm (FHNW & UC Berkeley)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **269** Type: **Poster**

Atmospheric temperature and density stratification for magneto-hydrodynamic models and spectro-polarimetric inversions

Numerical models of the solar atmosphere are an important tool in solar physics. Both, models and spectro-polarimetric inversion techniques require stratifications for the plasma temperature and density. For the case of explicit numerical schemes with high-order derivatives we require an isotropic diffusion equation for numerical stability. Otherwise, wiggles and inaccuracies can occur at steep temperature gradients in the solar transition region. We test a wide parameter range of the isotropic heat conduction to obtain realistic temperature gradients and feasible models. Our goal is to construct an atmospheric stratification that can serve as an initial condition for multi-dimensional models, as well as a more realistic reference atmosphere for inversions. To compensate for energy losses in the corona, we implement an artificial heating function that mimics the expected heat input from the field-line braiding mechanism. We find that our heating function maintains and stabilizes the obtained coronal temperature stratification. Unexpectedly, we find that higher grid resolutions may need larger diffusivity, contrary to the common understanding that high-resolution models are automatically more realistic and would need less diffusivity. The reason is that smaller grid spacing may represent steeper temperature gradients in the transition region, which has larger potential for numerical problems. We conclude that isotropic heat conduction is is required for explicit schemes with high-order numerical derivative. The Spitzer-type heat conduction alone would not be sufficient to maintain numeric stability.

Primary author: Ms PANDEY, Vartika (University of Graz)

Co-author: Dr BOURDIN, Philippe-A. (University of Graz)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **275** Type: **Poster**

The imaging evidence of low-energy cutoff and the status of spectral cross-calibration of HXI

In this talk, I will show the method to confirm the existence of the nonthermal component down to 6.5 keV in the observed X-ray spectrum of a microflare first reported by Glesener et al., 2020. We report the first imaging evidence for low-energy cutoff of energetic electrons in EM maps of >10 MK plasma, which first appeared as two coronal sources significantly above the chromospheric footpoints. This study reveals the important role of electron thermalization and low-energy cutoffs in the physical processes of microflares. The other topic is about the spectral cross-calibration of HXI onboard ASO-S. Cross calibration of different X-ray instruments is essential for solar X-ray joint studies and is particularly important for studies of X-ray directivity and 3-dimensional properties of HXR sources. I will present the preliminary results of the detector spectral calibrations of ASO-S/HXI by investigating its three total flux detectors, and cross-calibrations using SolO/STIX, Fermi/GBM, and Konus-Wind data. Although it is challenging to perform joint observation studies due to several factors, the close fit of the X-ray observations from different instruments still indicates a favorable perspective for joint studies.

Primary author: LI, Zhentong (Purple Mountain Observatory)

Co-authors: VERONIG, Astrid (University of Graz); Dr YU, Fu (Purple Mountain Observatory); Dr CHEN, Wei (Purple Mountain Observatory); Dr LIU, Wei (Purple Mountain Observatory); Dr GAN, Weiqun (Purple Mountain Observatory); Dr SU, Yang (Purple Mountain Observatory)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **276** Type: **Poster**

Complex interactions of the shock wave and ambient coronal structures

We present the study of the flare and coronal mass ejection (CME) event observed on 2 November 2021. The double-peak M1.7 GOES X-class flare originated from active region AR 12891 with has beta configuration of its photospheric magnetic field. The CME propagated strongly southward from the Sun-earth line. The CME-flare event was associated with a complex radio event consisting of multiple lane type II radio burst, Type III radio bursts and a Type IV continuum emission. The type II radio emission in the metric range shows two distinctive regimes indicating complex interaction of the shock wave and the ambient coronal structures. The type III radio bursts start mostly in the space-based observations suggesting the lack of the open field lines neighbouring the source region of the CME in the low corona and possible association with the shock wave (so called shock-associated type III bursts).

With the aim to understand complex relationship of the shock wave and its driver we combine analysis of radio observations and modelling of the fast Halo CME (velocity of about 1500 km/s). We employ direction finding technique for radio observations and the 3D MHD model EUHFORIA (European Heliosheric FORecasting Information Asset) for modelling of the CME and background solar wind.

Primary author: DESHPANDE, Ketaki (Royal Observatory of Belgium and KU Leuven, Belgium)

Co-authors: VALENTINO, Angelos (Centre for Mathematical Plasma Astrophysics, KU Leuven, Leuven, Belgium); MAGDALENIC, Jasmina (Royal Observatory of Belgium)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **277** Type: **Poster**

Radiometric cross-calibration of HRI/EUI on Solar Orbiter and AIA/SDO

The extreme ultraviolet High-Resolution Imager (HRI) of the EUI telescope onboard Solar Orbiter observes the solar corona in a ~5
$mathring$A passband near 174
$mathring$A with unprecedented high spatial resolution. We perform radiometric cross-calibration of the HRI and the EUV channels of the Atmospheric Imaging Assembly (AIA) telescope of the SDO in order to allow further mutual analysis of the observational data. We apply differential emission measure analysis using quasi-simultaneous images in 7 spectral channels –HRI and 6 AIA –and compare the real and the simulated images on the per-pixel basis across the mutual field-of-view. The comparison suggests that the real HRI images have 60-80% larger signal than predicted by the DEM analysis. While the DEM analysis is know to be error-prone, a reasonably good re-production of the original images justifies the approach. However, the observed difference in real/simulated signal suggests either AIA absolute calibration or EUI absolute calibration is off. We found also that adding of the HRI signal to the AIA-based DEM inversion procedure brings information about moderate ~1MK plasma. We discuss how the mutual observation can be used to better understand the physics of individual events or structures.

Primary author: SHESTOV, Sergei (Royal Observatory of Belgium)

Co-authors: ZHUKOV, Andrei (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence); BERGHMANS, David (Royal Observatory of Belgium, Solar-Terrestrial Centre of Excellence); AUCHÈRE, Frédéric (Institut d'Astrophysique Spatiale, France)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **285** Type: **Poster**

Cross-scale phase relationship of solar activity with solar wind parameters: a Space Climate focus

Understanding the relationship between solar activity and solar wind is crucial for exploring the interactions among different solar atmospheric layers and the dynamics within the heliosphere. In this work, we used data from five solar cycles to examine the phase relationship between a proxy of solar activity, namely the Ca II K index, and solar wind parameters at 1 AU, such as dynamic pressure and speed. By taking advantage of a powerful tool, the Hilbert-Huang Transform, we decomposed the signals into their intrinsic modes of oscillation and analyzed their phase differences. Despite preserving a certain degree of phase coherence, both solar wind parameters exhibit delayed variations relative to the Ca II K index on space climate scales, showing an anti-phase relationship until 1985, followed by quadrature phase differences. Additionally, we explored how the relationship between the Ca II K index and solar wind parameters varies across different time scales. Our results indicate the presence of a potential bifurcation in the phase-space of the Ca II K index and solar wind speed (dynamic pressure), with the time scale acting as a bifurcation parameter. This suggests that including longer time-scale components enhances the discernibility of their connection. This discovery could be pivotal for understanding the complex interactions between solar activity and solar wind, offering important implications for prediction and interpretation in space climate studies.

Primary author: REDA, Raffaele (University of Rome Tor Vergata)

Co-authors: GIOVANNELLI, Luca (University of Rome Tor Vergata); ALBERTI, Tommaso (INGV-- National Institute of Geophysics and Volcanology)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **288** Type: **Poster**

Ellerman Bomb detection in SST and SDO observations with Deep Learning.

Small-scale magnetic reconnection events have a fundamental role in the dynamics and evolution of active regions and flux emergence. To detect them, we can use Ellerman Bombs (EBs), events found across the photosphere of emerging active regions produced by the reconnection of strong field concentrations of opposite polarity. Their main characteristic is the enhancement of the wings of the Hα line while the core remains in absorption. Ellerman Bombs detection has been performed in many studies using high-spatial resolution ground-based telescopes, but limited to short time series and small fields of view. To overcome this, we aim to detect EBs in data sets from the Solar Dynamics Observatory (SDO), allowing for a broader study in both the temporal and spatial domain. However, detecting EBs in SDO is challenging due to the lower spatial resolution compared to high-spatial resolution observatories and the absence of Hα spectroscopy to identify them. To address this problem, we first apply deep learning techniques to observations from the Swedish 1-m Solar Telescope to automatically detect EBs using the Hα line. These detections are then used to translate the observational signatures of EBs to the spectral passbands of the Atmospheric Imaging Assembly (AIA) on board SDO. We do this by means of a neural network-based segmentation process, which we use to find UV EBs signatures. This opens the way to study the relation between small-scale magnetic reconnection events with active regions throughout all their lifetime and across the solar disk.

Primary author: Mr SOLER POQUET, Ignasi Josep (University of Oslo, Institute of Theoretical Astrophysics, Rosseland Centre for Solar Physics)

Co-authors: DIAZ BASO, Carlos Jose (Oslo University); ROUPPE VAN DER VOORT, Luc (Rosseland Centre for Solar Physics, University of Oslo)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **290** Type: **Poster**

Magnetohydrodynamic drag simulations for a coronal mass ejection

Interplanetary coronal mass ejections (ICMEs) are known to drive the most intense geomagnetic storms. The fastest ICMEs can travel from the Sun to 1 AU in less than 24 hours. In order to have fast and reliable time-of-arrival predictions, it is crucial to develop models that are both physically accurate and computationally efficient. A paramount example is the drag-based model (DBM), which describes an ICME as a rigid body subject to an aerodynamic drag exerted by the background solar wind. However, as already hinted by early simulations, such a drag process has a magnetohydrodynamic nature and the aerodynamic DBM might not be the most accurate description. We present results of numerical experiments using high-resolution 2.5D MHD simulations of an ICME moving in different solar wind environments, aimed at improving such model. We focus on studying the resulting drag force both dynamically and parametrically. Thanks to a semi-Lagrangian approach (Expanding Box Model) and its resulting high resolution, we are able to include the effects of expansion, erosion (magnetic reconnection), and turbulence. We present preliminary results on the ICME tracking, deceleration, and drag estimates, and discuss their implications in the context of space weather.

Primary author: SANGALLI, Mattia (Università degli Studi di Firenze)

Co-authors: VERDINI, Andrea (Università degli Studi di Firenze); LANDI, Simone (Università degli Studi di Firenze); PAPINI, Emanuele (INAF-IAPS); NAPOLETANO, Gianluca (Università degli Studi di Firenze)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **291** Type: **Poster**

Energy diagnostics of flare-accelerated electron beams with X-ray and Radio data from Solar Orbiter

Energetic electrons from solar flares can move downward to produce X-rays in the chromosphere and upward to generate type III radio bursts in space. Previous studies found a good temporal correlation but a weak intensity correlation between both emissions due to different emission mechanisms. Theoretically, a link between the speed of outward electron beams (from radio) and the energy density of downward electrons (from X-rays) has been predicted. The **Solar Orbiter mission**, equipped with STIX and RPW instruments, allows for simultaneous X-ray and radio observations to test this theory.
We present results from 36 flares observed by STIX (4-150 keV) and associated with type III radio bursts detected by RPW (<10 MHz). Using X-ray spectroscopy, we obtained the electron spectral index and electron number during the HXR peak to estimate power. We derived the Type III exciter speed using the rise and peak times of the time profiles (V_front an V_peak, respectively) in the 0.4-4 MHz range, finding a V_p/V_f ratio of 0.77 ± 0.07, aligning with previous studies (@ 30-70 MHz, 0.8 ± 0.06) . We observed a correlation between electron power (E>25keV) and V_f **(cc=0.48)**, and a weaker one with V_p **(cc=0.3)**. The peak radio intensities correlate well with the electron spectral index **(CC=0.72)**. These findings suggest that while electron acceleration is temporally correlated, the energy distribution of escaping and confined electrons may be influenced by the geometry of the reconnecting magnetic field. As predicted by simulations, the radio intensity increases with energy density in the accelerated beams.

Primary author: PAIPA LEON, David (LESIA - Observatoire de Paris)

Co-authors: REID, Hamish (University College London, UK); MAKSIMOVIC, Milan (LESIA, Observatoire de Paris, Meudon); VILMER, Nicole (LESIA-Paris Observatory- PSL)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **292** Type: **Poster**

Solar observations with the Atacama Large Aperture Submillimeter Telescope (AtLAST)

The **Atacama Large Aperture Submillimeter Telescope (AtLAST)** is a proposed single-dish full-steerable 50m telescope that would be located at 5100m altitude in the Chilean Andes near ALMA. Among a large range of scientific topics, AtLAST would be able to observe the Sun, probing the thermal and magnetic structure of the **solar chromosphere**, chromospheric heating, flares, prominences, the solar activity cycle, and much more. A truly novel observational aspect would be a fast-scanning mode to construct full-disk maps at multiple frequencies, resulting in high-cadence sequences and daily maps, thus covering the large range of relevant timescales with the same instrument, which would provide data complementary to observations at shorter wavelengths with, e.g., the European Solar Telescope (EST). In addition, AtLAST observations of our host star would have direct implications for stars and their impact on exoplanets in general.

Here we summarise the white paper on solar observations with AtLAST and highlight the need for an instrument with a large number of detector elements covering a wide frequency range.

Primary author: Dr WEDEMEYER, Sven (Rosseland Centre for Solar Physics, University of Oslo, Norway)

Co-authors: ATLAST SOLAR/STELLAR SCIENCE WORKING GROUP; KIRKAUNE, Mats (Rosseland Centre for Solar Physics, University of Oslo)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **295** Type: **Poster**

Long-Period of Plasma and Magnetic-Helicity Oscillation Prior to Three C-class Flares

The objective of this work is to identify various periods of magnetic helicity and detect the long-periods plasma oscillations in an Active Region NOAA12353 prior to a series of C-class flares in the lower solar atmosphere.
To analyse the magnetic helicity flux in the lower solar atmosphere, linear force-free field extrapolation was used to construct a model of the magnetic field structure of the active region. Subsequently, the location of long-period oscillations in the active region was probed by examining the spectral energy density of the measured intensity signal in the 1700 Å, 1600 Å, and 304 Å channels of the Atmospheric Imaging Assembly (AIA) of the Solar Dynamics Observatory (SDO). Significant periods of oscillations were determined by means of 3D-wavelet analysis. We report the presence of different long periods oscillation in the lower solar atmosphere before and after the flare events.

Primary author: WISNIEWSKA, Aneta (Astronomical Institute Slovak Academy of Sciences)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **296** Type: **Poster**

Investigating the effect of statistically-averaged helicity condensation on ambient increase in the Solar Open Flux

A key problem faced by global models of the solar corona is a consistent underestimation of the amount of Open Flux. Recent studies have shown that introducing bipole twist or helicity condensation to non-potential global models can partially resolve this disagreement between simulated and measured values of the Solar Open flux. Here, we disentangle these effects to focus entirely on the extent of the contribution from helicity condensation to the Open Flux. We make use of global magnetofrictional simulations to model the amount of open flux and its spatial distribution over several solar cycles based on Kitt-Peak synoptic magnetograms. From this we show that statistically-averaged helicity condensation leads to both an ambient increase of Open Flux and a sporadic incease. Additionally, single-case analysis of the relationship between helicity condensation and open flux reveals some fine-detail behaviour that is otherwise obscured by the large-scale temporal analysis.

Primary author: KLOWSS, Jonah (University of St Andrews)

Co-author: Prof. MACKAY, Duncan (University of St Andrews)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **297** Type: **Poster**

Propagation and reflection of MHD waves in the solar wind

Spacecrafts such as Parker Solar Probe (PSP) and Solar Orbiter (SolO) study the solar atmosphere by making in-situ and remote observations at an unprecedented spatial and temporal resolution, shedding light on coronal heating and solar wind acceleration mechanisms. Alfvenic fluctuations such as switchbacks and pure Alfven waves are some of major carriers of magnetic energy, but the energy dissipation mechanisms remain unclear. Phase mixing can be an effective mechanism, that has mostly been studied in the context of closed magnetic field structures such as coronal loops. Along open field lines, trapping and/or dissipating wave energy becomes more difficult. Non-uniformities in the medium can, in general, reflect a fraction of the input wave energy. Not only does this increase the opportunities for energy dissipation, but also has seismological applications in the sense that the transmitted wave spectrum contains information about the non-uniformities in the underlying medium. Using magnetohydrodynamic modelling, we aim to understand these phenomena in the context of a spherically expanding background solar wind. Therefore, our simulations encompass a numerical domain from the chromosphere where waves are generated to the PSP and SolO perihelia and whose propagation and dissipation are studied in an extended solar atmosphere with a supersonic and superalfvenic background solar wind. Our model, in conjunction with space-based solar wind observations, provides an estimate of the conditions and constraints for maximal amount of wave energy trapping available for coronal heating and solar wind acceleration in terms of inherent spatial and temporal scales.

Primary author: KUMAR, Anmol (University of St Andrews)

Co-authors: DE, Ineke (University of St Andrews); PAGANO, Paolo (Università degli Studi di Palermo); HOWSON, Thomas (Abertay University, University of St Andrews)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **300** Type: **Poster**

Using the Sun as Rosetta stone to study the properties of other solar-like systems

We present our new approach to characterize
solar-like stars and their interaction with hosted exoplanets in analogy to the Sun-Earth system. Our investigation allows us to obtain not only a highly accurate characterization of the mother star, but also to study the impact of the star's rotational and activity history on the evolution of its exoplanets.
This information, coupled with
the precise age estimated by asteroseismology, allows determining how long an atmosphere of terrestrial type could resist to the action of stellar wind and the XUV flux enabling to directly quantify the portion of the atmosphere which could potentially be eroded.

Primary author: Dr DI MAURO, Maria Pia (Istituto Nazionale di Astrofisica (INAF))

Co-authors: PEZZOTTI, Camilla (University of Liège); BERRILLI, Francesco (Università degli Studi di Roma "Tor Vergata"); GIOVANNELLI, Luca (University of Rome Tor Vergata); REDA, Raffaele (University of Rome Tor Vergata)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **303** Type: **Poster**

Modeling the Propagation of CMEs with COCONUT: Implementation and application of the RBSL Flux Rope Model

Coronal mass ejections (CMEs) are rapid eruptions of magnetized plasma that occur on the Sun. They are known to be the main drivers of adverse space weather. The accurate tracking of their evolution in the heliosphere in numerical models is of the utmost importance for space weather forecasting. We implement the RBSL flux rope model in COCONUT, a new global coronal MHD modeling, to simulate the propagation of CMEs resulting from the eruptions of the flux rope with a complicated shape from the solar surface to 25 solar radii. Hereafter, we investigate the impacts of the morphology of flux ropes on their resulting CMEs. As such, we can establish a bridge between the CMEs at 20 solar radii and their progenitors in solar source regions.his work demonstrates the potential of the RBSL flux rope model in reproducing CME events that are more consistent with observations. Our findings strongly suggest that magnetic reconnection during the CME propagation plays a critical role in destroying the coherent characteristics of a CME flux rope.

Primary authors: LANI, Andrea (KU Leuven); SCHMIEDER, Brigitte (Observatoire de Paris); GUO, Jinhan (KU Leuven / Nanjing University); LINAN, Luis (CmPA, KU Leuven); Prof. CHEN, Pengfei (Nanjing University); Prof. POEDTS, Stefaan (KU Leuven); Prof. GUO, Yang (Nanjing University); Mr NI, Yiwei (Nanji)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **304** Type: **Poster**

Infrared spectropolarimetry of C class solar flare

The influence of solar flares on the dynamics of lower atmospheric plasma is not yet fully understood. We performed full-Stokes spectropolarimetric observations of active region NOAA 3363 on GREGOR Infrared Spectrograph (GRIS) during consecutive C class flares on July 16, 2023. The near-infrared spectral interval covered photospheric Si I 10827˚A and Ca I 10839˚A lines and chromospheric He I 10830˚A triplet line. Besides the enhanced emission of He I 10830˚A triplet, the upper photospheric line Si i 10827˚A also showed a significant intensity increase. The intensity of the Si I line was increased after several minutes of He I enhancement, which indicates slow energy transfer from the chromosphere to the upper photosphere. We speculate that the heat transfer by thermal conduction from the formation height of He I to the formation height of the Si I line is responsible for the observed time delay.

Primary authors: Dr VASHALOMIDZE, Zurab (Astronomical Institute SAS); ZAQARASHVILI, Teimuraz (IGAM, Institute of Physics, University of Graz); BENKO, Martin (Astronomical Institute Slovak Academy of Sciences); Dr KURIDZE, Davit (National Solar Observatory); GÖMÖRY, Peter (Astronomical Institute Slovak Academy of Sciences); RYBAK, Jan (Astronomical Institute, Slovak Academy of Sciences, Tatranska Lomnica, Slovakia); COLLADOS, Manuel (Instituto de Astrofísica de Canarias)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **309** Type: **Poster**

Heliospheric Space Weather Centre tools for space weather monitoring

The Heliospheric Space Weather Centre (HSWC) is an ALTEC, INAF –OATo, and UniGe joint project aimed at providing and supporting services related to the heliosphere. It currently hosts two tools developed by ALTEC and INAF: the Geo Magnetic Effectiveness (H103d) and the CME propagation prediction (H103e). The tools are part of the SWESNET project, within the ESA Space Weather programme. The algorithms, developed by INAF, are integrated into ALTEC's infrastructure, which handles data retrieval, scientific product generation, storage, and web interface.
The H103d tool uses data from the DSCOVR instrument to compute magnetic helicity, used to identify geo-effective events. It analyzes near real-time measurements and generates 7-day plots of magnetic field, solar wind speed, proton density, proton temperature, DST index, magnetic helicity spectrogram, and integrated magnetic helicity.
The H103e tool employs data from DSCOVR/FC and LASCO/C2-C3. Its algorithms detect halo CMEs, identify CME features, model solar wind, and model CME propagation. The pipeline computes 48 solar wind and proton density maps daily from DSCOVR/FC data over the previous 28 days, and identifies earthward CMEs, calculates their parameters and arrival time.
ALTEC infrastructure is being upgraded to host AI support tools. In the next future, AI-based modules will be added to both the H103d, in the context of AIxtreme-I project, and H103e tools; a third tool dedicated to predict the occurrence of intense solar flares within next 24 hours is currently in the integration phase.
The presentation will cover the pipelines, components, and working mechanisms of current and future tools.

Primary authors: PINNA, Federico (ALTEC); Dr SOLITRO, Filomena (Aerospace Logistics Technology Engineering Company - ALTEC); Dr TOLOMEI, Leonardo (Aerospace Logistics Technology Engineering Company - ALTEC); Dr MESSINEO, Rosario (Aerospace Logistics Technology Engineering Company - ALTEC); Dr LEUZZI, Chiara (Aerospace Logistics Technology Engineering Company - ALTEC); SUSINO, Roberto (Istituto Nazionale di Astrofisica (INAF)); TELLONI, Daniele (Istituto Nazionale di Astrofisica (INAF)); Dr FINESCHI, Silvano (Istituto Nazionale di Astrofisica (INAF)); GUASTAVINO, Sabrina (Department of Mathematics, Università degli Studi di Genova); PIANA, michele (MIDA, dipartimento di matematica, università di genova); Dr BEMPORAD, Alessandro (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **311** Type: **Poster**

MOF: the Ground Support to Metis Data and Operations

METIS is the coronagraph of the scientific payload of Solar Orbiter, a joint ESA-NASA mission aiming at studying the Sun poles and the circumsolar region. METIS operations are handled via the Metis Operations Facility (MOF), which is built, run, and maintained by ALTEC in close collaboration with INAF. MOF empowers the scientific analysis and exploitation of data acquired by METIS in different ways:

• Data retrieval and processing: the METIS raw telemetry is fetched on a daily basis from Mission Operation Center (MOC) and transformed up to L2 data products;
• Data archival: METIS data products are indexed and preserved with the aim of enabling exploitations of METIS data in space weather and solar science applications;
• Data exploration: the scientific team has the capability to explore the MOF archive by searching for METIS data products exploiting a wide set of scientific keywords;
• Data analysis and validation: reports about METIS data products are generated in order to allow the scientific team to detect observed solar events of interest like Coronal Mass Ejections (CMEs) and flares. Validated data is eventually published to the ESA Solar Orbiter Archive (SOAR);
• TM/TC Monitoring: METIS telemetry stored in MOF can be exploited to perform further analysis about the instrument and spacecraft status.

In the talk, MOF capabilities and the current state and nominal functioning will be presented. Moreover, future plans and perspectives to further exploit METIS data in space weather and big data and AI related applications will be discussed.

Primary author: CHIARAMIDA, Vincenzo (ALTEC SpA)

Co-authors: Mr VILLA, Alfredo (ALTEC SpA); Mr CALABRESE, Davide (ALTEC SpA); PINNA, Federico (ALTEC); SOLITRO, Filomena (ALTEC); Mr MARINO, Francesco (ALTEC SpA); BRAMANTE, Lorenzo; Mr MESSINEO, Rosario (ALTEC SpA); Mr PISCIOTTA, Stefano (ALTEC SpA)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **312** Type: **Poster**

3D recostruction of a CME with polarimetric technique

On October 3, 2023, around 12:45 UT, a prominence erupted from the active region located at 18°N, 20°W, as observed by the Full Sun Imager/Extreme Ultraviolet Imager (FSI/EUI) on board the Solar Orbiter. This eruption was followed by a partial halo coronal mass ejection (CME) and a CME-driven shock, confirmed by the detection of a Type II radio burst by . In order to estimate the CME plasma electron density and to infer the 3D structure of the CME by using a single point of view, we applied the polarization-ratio technique to the Metis white light data (polarized and total brightness). Additional constraints to the 3D reconstruction were provided by observations from other LASCO-C2 on SOHO and COR1 and COR2 on STEREO-A. By using UV data from Metis and considering the radiative and/or collisional excitation, also the CME electron temperature can be estimated. This work thus provides new information on the thermodynamic evolution of CMEs in the inner corona

Primary author: FRASSATI, Federica (Istituto Nazionale di Astrofisica (INAF))

Co-authors: Dr BEMPORAD, Alessandro (Istituto Nazionale di Astrofisica (INAF)); TEAM, Metis

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **314** Type: **Poster**

A catalog of CME-ICME lineup events

An accurate assessment of our current space weather modeling is necessary due to progress in space weather research. Any validation framework needs suitable qualitative data for consistent validation procedures. The qualitative data also contributes to the refinement of the model and hence better forecasting ability. In alignment with this objective specifically for CME events, we present a newly prepared dataset of CME-ICME lineup events. This dataset includes in-situ observations from various spacecraft like Messenger, Venus Express, Maven, Stereo-A/B, Solar Orbiter, Bepi Colombo, Parker Solar Probe, Wind, etc, with detailed CME analysis performed by Space Weather Database of Notifications, Knowledge, Information (DONKI) developed at the Community Coordinated Modeling Center (CCMC). Apart from CME-ICME information, the dataset also possesses the necessary information about Probabilistic Drag Based Model (P-DBM) quantities. The dataset is publicly available to provide a valuable resource for model validation and to compare the performance with other available CME propagation models.
Our work offers a unique opportunity to refine CME propagation models, as ICMEs have been observed at multiple targets across a wide range of heliocentric distances. By utilizing this dataset, researchers can better understand the dynamics of CME propagation and improve the forecasting methods.

Primary author: MUGATWALA, Ronish

Co-authors: DEL MORO, Dario (Università di Roma Tor Vergata); Mr FRANCISCO, Gregoire; Mr CHIERICHINI, Simone; ERDELYI, robertus (univ of sheffield)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **315** Type: **Poster**

Sun cubE onE (SEE): a CubeSat Mission for High-Energy Solar Observations

The SunsCube One (SEE) mission, currently in the early design stages, is being built by a team led by the University of Roma Tor Vergata. This mission is one of several small satellites planned by the Italian Space Agency (ASI) under ALCOR program. SEE proposes a 12U CubeSat to investigate gamma-ray, X-ray, and ultraviolet (UV) solar emissions. SEE aims to improve our understanding of space weather and Sun-Earth interaction from Low Earth Orbit (LEO). SEE's scientific payload is specifically designed for two key investigations. First, X and Gamma SEE's scientific payload is designed to investigate the energy spectrum of solar flares from the soft X-rays to the high-energy gamma rays. Importantly, the instrument will achieve this with a high time sampling rate, allowing for a detailed analysis of the rapid fluctuations that occur during a flare event. Second, the mission will monitor solar activity by capturing full-disk images of the Sun in the specific wavelength of the Magnesium II (Mg II) doublet at 280 nm, utilizing a dedicated full-disk imager. This is valuable because UV radiation heavily influences both Earth's upper atmosphere, impacting space weather, and the lifespan of orbiting debris. SEE will leverage data from existing space and ground-based observatories, including those focusing on solar features (Solar Orbiter, IRIS, SDO, Aditya-L1, TSST), high-energy particles (GOES, CSES), and Earth's magnetic field (geomagnetic data). This multi-instrument, multi-wavelength, and multi-messenger approach will provide a comprehensive picture of solar activity and its impact on Earth.

Primary authors: GIOVANNELLI, Luca (University of Rome Tor Vergata); BERRILLI, Francesco (Università degli Studi di Roma "Tor Vergata"); MARCELLI, Laura (INFN, Rome Tor Vergata); CASOLINO, Marco (INFN, Rome Tor Vergata); CURTI, Fabio (Sapienza University of Rome, School of Aerospace Engineering); DE GUZMAN, Mark Anthony (Sapienza University of Rome, School of Aerospace Engineering); DI TANA, Valerio (ARGOTEC S.r.l.); PATTANARO, Lorenzo (ARGOTEC S.r.l.); MARMONTI, Matteo (Optec S.p.A.); TERRACINA, Annalisa (NEXT Ingegneria dei Sistemi S.p.A.); ROSSI, Alessandro (NEXT Ingegneria dei Sistemi S.p.A.); BERRETTI, Michele (Università degli Studi di Trento, Università degli Studi di Roma "Tor Vergata"); CASARA, Letizia (University of Rome Tor Vergata, Physics Department); DEL MORO, Dario (Università di Roma Tor Vergata); CALCHETTI, Daniele (Max-Planck-Institute for Solar System Research); CANTORESI, Matteo (Dipartimento di Fisica - Università di Roma Tor Vergata); CHIERICHINI, Simone (University of Rome Tor Vergata, Physics Department); GIRI NAIR, Archana (University of Rome Tor Vergata, Physics Department); KONOW, Fallon (University of Rome Tor Vergata, Physics Department); LUCAFERRI, Lorenza (University of Rome Tor Vergata, Physics Department); NIGRO, Giuseppina (University of Rome Tor Vergata, Physics Department); PENZA, Valentina (Università "Tor Vergata" - Roma); PUCACCO, Giuseppe (University of Rome Tor Vergata, Physics Department); REDA, Raffaele (University of Rome Tor Vergata); SCARDIGLI, Stefano (University of Rome Tor Vergata, Physics Department); Prof. TOMBESI, Francesco (Tor Vergata University of Rome & INAF); FRANCISCO, Grégoire (University of Rome Tor Vergata); MAZZOTTA, Pasquale (University of Rome Tor Vergata, Physics Department); MUGATWALA, Ronish; REALI, Enzo (University of Rome Tor Vergata, Physics Department); ALBERTINI, Marisa (Optec S.p.A.); BENIGNO, Nicolò (ARGOTEC S.r.l.); IOVANNA, Francesco (ARGOTEC S.r.l.); MARCANIO, Attilio (NEXT Ingegneria dei Sistemi S.p.A.); SARNARI, Flaminia (NEXT Ingegneria dei Sistemi S.p.A.); TURI, Antonio (ARGOTEC S.r.l.); NATALUCCI, Silvia (Agenzia Spaziale Italiana); URBAN, Daniele (Agenzia

Spaziale Italiana); ILLIANO, Simone (Agenzia Spaziale Italiana); PLAINAKI, Christina (Italian Space Agency); CARPENTIERO, Rita (Agenzia Spaziale Italiana)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **319** Type: **Poster**

COCOMAG: color-coded magnetograms as probes of active region evolution and complexity

We are proposing a visualization of vector magnetograms whereby the three components of the photospheric magnetic field vector are combined into RGB colored maps, creating color-coded magnetograms (COCOMAGs). In this configuration the primary and secondary colors represent magnetic field with different orientation. The areas occupied by different color hues are extracted, creating appropriate time series (color curves). The resulting colored maps and color curves are used as proxies of the active region evolution and its complexity. The morphology exhibited in COCOMAGs is associated to typical features of active regions, such as sunspots, plages, and sheared polarity inversion lines. In complex regions, extended, twisted flux systems appear as continuous, color processions, while abrupt color changes signify sheared polarity inversion lines. Active regions in their decay phase are dominated by rather vertical magnetic field (pixels with green color), indicating a gradual relaxation of the magnetic field configuration. The color curves, which represent the area coverage of magnetic field with different orientation, exhibit varying degree of correlation with active region complexity. Particularly the red and magenta color curves, which represent strong, purely horizontal magnetic field, seem to be good indicators of future flaring activity. The proposed visualization can be adapted to different color tables, it facilitates a comprehensive view of the evolution of active regions and their complexity and offers a framework for pattern recognition, feature extraction and flare prediction schemes.

Primary author: KONTOGIANNIS, Ioannis (Leibniz-Institute for Astrophysics Potsdam (AIP))

Co-authors: Dr PIETROW, A.G.M. (Leibniz Institute for Astrophysics Potsdam (AIP) Germany); Dr DRUETT, M. (Centre for Mathematical Plasma Astrophysics, Department of Mathematics,KU Leuven); Dr DINEVA, E. (Centre for Mathematical Plasma Astrophysics, Department of Mathematics, KU Leuven); Dr VERMA, M. (Leibniz Institute for Astrophysics Potsdam (AIP) Germany); Prof. DENKER, C. (Leibniz Institute for Astrophysics Potsdam (AIP) Germany)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **325** Type: **Poster**

Investigating the relation between the measured solar wind speed and the extrapolated magnetic field configuration in the solar corona

Our understanding of the physics behind the origin and the evolution of the solar wind in the low/middle corona depends on our capability of gathering information on the characteristics of the solar wind and on its interaction with the magnetic field within this region. Despite the possibility of acquiring in situ measurements closer to the Sun provided by the Parker Solar Probe and the Solar Orbiter missions, the region below 10 solar radii remains still impenetrable. Our knowledge of this portion of the solar corona relies on the acquisition of remote sensing instruments and on models. This work aims at deriving new insights on the relationship between the configuration of the coronal magnetic field and the measured solar wind speed. We combined solar wind speed measurements obtained by exploiting the Doppler dimming technique using SOHO/UVCS and SOHO/LASCO-C2 data, with the configuration of the magnetic field lines derived by using the Wang-Sheeley-Arge (WSA) model starting from photospheric magnetic field measured. This statistical analysis has been done for different Carrington Rotations. In this work, we provide a detailed description of the used method and of the obtained results explaining how the same technique can be used on data acquired by other remote sensing instruments capable of measuring the outflow speed of the solar wind in corona such as Metis on-board Solar Orbiter and CODEX.

Primary author: CASTI, Marta (The Catholic University of America at NASA/GSFC)

Co-authors: ARGE, Charles N. (NASA Goddard Space Flight Center, USA); Dr BEMPORAD, Alessandro (Istituto Nazionale di Astrofisica (INAF)); GIORDANO, Silvio Matteo (Istituto Nazionale di Astrofisica (INAF)); HENNEY, Carl (Air Force Research Laboratory, USA)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **326** Type: **Poster**

State-of-the-art Image Slicer developments to Enable 2D Extreme Ultraviolet Imaging Spectroscopy in Seconds.

Observations in the Extreme Ultraviolet (EUV) are crucial for understanding the dynamics of the solar corona. The current EUV observing method utilises an entrance slit and scans over a field of view to build up 2D imaging spectroscopy. This scanning results in low-cadence images on the order of minutes which misses fundamental processes that occur on faster timescales. The application of image slicers for EUV integral field spectrographs is therefore revolutionary as they will enable observations of EUV spectra from an entire 2D field of view in seconds. However, the current technology limits their use, with future image slicer developments focussing mainly in two key parameters: the reduction of the slicer mirror width and the improvement of the surface roughness. We present results from a recent study that allows higher resolution better surface roughness to reduce stray light, and innovative ideas when using these slicers for highly efficient Integral Field Spectrographs. We show the thinnest metal image slicers that have been produced in the world to date. These improvements in image slicer technology are one big step towards implementing the Spectral Imaging of the Solar Atmosphere (SISA) instrument proposal for observing important spectroscopic diagnostics for characterization of solar coronal and flare plasmas.

Primary authors: Dr ROSARIO CALCINES, Ariadna (University of Durham); REID, Hamish (University College London); WHITE, Paul (University of Durham); MATTHEWS, Sarah (UCL/MSSL)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **328** Type: **Poster**

Correlation approach to nanoflare heating diagnostics

The solar corona is hypothesized to be heated via small-scale random impulsive events, i.e., nanoflares. Recent DEM analysis results indicate that nanoflare generation frequency may be noticeably higher than the characteristic cooling rate of coronal plasma. Hence, individual nanoflare lightcurves are hardly distinguishable from the seemingly uniform background, complicating standard event-based statistical methods to study these phenomena. We believe that process-based techniques may be more effective. We propose a new model-based correlation approach to probe the main parameters of nanoflares, such as their frequency and duration. The latter is directly associated with the energy release time crucial for physical interpretation. We present and discuss the results of applying the algorithm to a range of synthetic data and observations provided by the latest space-bourne solar observatories.

Primary author: ULYANOV, Artem (Max Planck Institute for Solar System Research)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **329** Type: **Poster**

Kinetic Models of Solar Wind Current Sheets

In-situ measurements of kinetic-scale collisionless current sheets in the solar wind have shown that such current sheets are often approximately force-free despite having a plasma beta of the order of one. Statistical analyses have found that the plasma density and temperature can vary across a current sheet in an anti-correlated manner such that the plasma pressure remains essentially uniform across the sheet.

Kinetic models of force-free collisionless current sheets have been developed which allow for asymmetric plasma density and temperature profiles. The earliest of these models introduced the required asymmetry by adding an additional term to both the ion and electron distribution functions. Recent models instead try to introduce the required asymmetries by modifying only the electron distribution function. However, the resulting equilibrium problem is non-linear in nature. An approximate solution was found under the assumption that the magnetic field is unchanged.

We present an improved approximate solution which drops this assumption and allows for changes in the magnetic field. We also present the results of a full numerical solution to the non-linear equilibrium problem. It is shown that, for the given forms of the electron and ion distribution functions, it does not seem possible to model the observed electron density and temperature asymmetries correctly when only the electron distribution function is modified.

Primary author: Ms BOSWELL, Sophie (School of Mathematics and Statistics, University of St Andrews)

Co-authors: Prof. NEUKIRCH, Thomas (University of St Andrews); Dr VASKO, Ivan (W. B. Hanson Center for Space Sciences, University of Texas at Dallas, USA); Dr ARTEMYEV, Anton (Institute of Geophysics and Planetary Sciences, University of California, Los Angeles, USA); Dr ALLANSON, Oliver (School of Engineering, Space Environment and Radio Engineering, University of Birmingham, UK)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **331** Type: **Poster**

Estimating the helicity and electromotive force with SolarOrbiter in-situ data of an iCME

During inter-planetary coronal mass ejections we expect faster solar wind to push into slower ambient wind, leading to the formation of super-sonic shocks. This may trigger turbulence to amplify magnetic fields stronger than expected by pure compressional effects, known as turbulent dynamo action. The turbulent nature of iCME fronts can be uncovered by computing the electromotive force. Peaks in the electromotive force reveal the arrival time of such fronts and their following sheath regions at the spacecraft. Since the magnetic helicity is conserved, we expect the same handedness as in the coronal source region of the outbreak. From an asymmetric double peak in the electromotive force, we can find this helicity handedness in an event observed by the MAG and SWA-PAS instruments around November 4, 2021. We compare this particular event with a series of previously recorded events from the Helios missions observed in the inner heliosphere. A scaling law on the magnitude of the electromotive force shows how these events are expected to decay while propagating to 1 au. This knowledge allows to automatically identify iCME shocks in heliospheric mission data with simple means. Future missions may use this technique to automatically switch the instrument observing modes to higher cadence, in order to fully capture dynamic events.

Primary author: Dr BOURDIN, Philippe-A. (University of Graz)

Session Classification: Coffee break and poster session 2

Track Classification: Space weather and the solar-heliospheric connections

Contribution ID: **338** Type: **Poster**

Probing the substructures of solar flare ribbons

Solar flares are among the most spectacular and energetic phenomena in the solar system, and understanding their driving mechanisms is of paramount importance in solar physics. It is widely accepted that magnetic reconnection is the primary mechanism behind solar flares; allowing for the conversion of magnetic energy into plasma energy, resulting in the acceleration of particles such as electrons and ions. These accelerated particles form electron beams that deposit energy into the coronal plasma locally, and transfer energy globally when they impact the chromosphere, responsible for the characteristic ribbon-shaped emission of Hydrogen 656.3nm (Hα). Using the high-resolution Swedish 1-m Solar Telescope (SST) and CRisp Imaging SpectroPolarimeter (CRISP), we studied the substructures of Hα ribbons in unprecedented temporal and spatial resolution (i.e. 43 km per pixel and a cadence varying in time between 0.2 and 1.2 s). We have identified and analyzed small-scale substructures within the ribbons, referred to as "riblets". We present our definition of riblets and a detailed analysis of their statistical and kinematic properties during an X-class solar flare observed on 10 June 2014. By examining the riblets at this resolution and exploring their evolution in the context of SDO/AIA 304 A and RHESSI contours, we can probe the microphysics of energy deposition in the chromosphere with a high degree of precision. We present our analysis of a new class of rapidly evolving sub-structures with mean lifetimes of 11s that exhibit linear and non-linear dynamics, providing valuable constraints on 1D radiation hydrodynamic models of electron beam physics.

Primary author: SINGH, Vishal (Northumbria University)

Co-authors: SCULLION, Eamon (Northumbria University); BOTHA, Gert (Northumbria University); DRUETT, Malcolm (Center for mathematical Plasma Astrophysics, Department of Mathematics, KU Leuven, Celestijnenlaan 200B, B-3001 Leuven, Belgium); JEFFREY, Natasha (Northumbria University)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **339** Type: **Poster**

FastQSL: A Fast Computation Method for Quasi-separatrix Layers

Magnetic reconnection preferentially takes place at the intersection of two separatrices or two quasi-separatrix layers, which can be quantified by the squashing factor Q, whose calculation is computationally expensive due to the need to trace as many field lines as possible. FastQSL is developed for obtaining Q and the twist number, with the performance of millions of Q values per second. FastQSL supports both uniformed and stretched grids, the support of spherical coordinates is extended recently.

Primary author: CHEN, Jun (Purple Mountain Observatory, Chinese Academies of Sciences)

Session Classification: Coffee break and poster session 2

Track Classification: Diagnostic tools and numerical methods in solar physics

Contribution ID: **342** Type: **Poster**

Non-Radial and Multiple Interacting CMEs: A Multi-Spacecraft Perspective Combining Coronagraphs and Heliospheric Imagers

An accurate determination of the trajectory of Coronal Mass Ejections (CMEs) is crucial for space weather forecasting and assessing whether or not they will impact Earth. Deviation of CME trajectory from a radial propagation is often observed as a consequence of gradients in the local magnetic pressure or due to CME-CME interactions visible within the coronagraphs' field of view. The combination of coronagraphic and heliospheric observations can provide deeper insights into these phenomena, offering valuable information for future space weather forecasting.

On 2023 September 24, several spacecraft observed four non-radial and interacting CMEs. Our study presents an in-depth analysis of these CMEs for which the 3D trajectories are determined through a Graduated Cylindrical Shell forward-modeling technique combining full-disk imagers and coronagraphs onboard STEREO-A, SOHO, and Solar Orbiter, and making use, for the first time, of both the heliospheric imagers onboard Solar Orbiter and Parker Solar Probe. This multiple-viewpoint approach allowed us to determine eventual deflections in longitude or latitude from the source location.

Our analysis revealed CME-CME interactions in the very low corona. In particular, the second and third CMEs interacted causing a deflection of the second post-CME current sheet and producing a "bouncing effect" that deflected the two CMEs in opposite directions of about 15° in latitude. Additionally, strong magnetic fields near the source regions caused a 25° latitudinal deflection of the fourth CME. Finally, the interaction between the flank of the third CME with the post-CME outflow of the second one showed some interesting macro-scale interaction patterns.

Primary author: Dr LIBERATORE, Alessandro (NASA Jet Propulsion Laboratory, California Institute of Technology)

Co-authors: Dr LIEWER, Paulett (NASA Jet Propulsion Laboratory, California Institute of Technology); Dr CAPPELLO, Greta (Institute of Physics, University of Graz); Dr TEMMER, Manuela (Institute of Physics, University of Graz); Dr VOURLIDAS, Angelos (Johns Hopkins University, Applied Physics Laboratory); Prof. VELLI, Marco (Department of Earth, Planetary, and Space Sciences, University of California, Los Angeles)

Session Classification: Coffee break and poster session 2

Track Classification: Multi-scale energy release, flares and coronal mass ejections

Contribution ID: **343** Type: **Poster**

The extremely strong photospheric electric currents of active region NOAA 13664

Active region NOAA 13664 has been so far the most flare-prolific active region of the present solar cycle, producing eight X- and several M- and C-class flares, causing the strongest geomagnetic storm since 2003. In this study, the evolution of the non-neutralized (net) electric currents is examined, along with that of the emerging flux. The net currents were calculated using a method based on image segmentation and error analysis of the photospheric vector magnetograms provided by the Helioseismic and Magnetic Imager (HMI). At its full extent NOAA 13664 became the second largest in area since 2010, second only to NOAA 12192. The region was already an evolving δ-type region when it rotated into view. A series of strong magnetic flux emergence events in its vicinity led to an extremely complex magnetic configuration, with intense shearing motions over almost the entire area of the region. In comparison to the most extended and the most flare prolific regions observed since the beginning of HMI observations, NOAA 13664 had by far the strongest net electric currents. The development of these currents is attributed to a unique case of interaction between a complex δ-type region, which already contained strong net currents, and new highly-deformed flux systems.

Primary author: KONTOGIANNIS, Ioannis (Leibniz-Institute for Astrophysics Potsdam (AIP))

Session Classification: Coffee break and poster session 2

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