



Book of Abstracts

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Splinter meetings

Review of SOOPs and out-of-ecliptic observations (coord. by D. Spadaro)

Coordinated observations with Metis and ASPIICS (coord. by S. Fineschi and A. Zhukov)

Workshop – programme

Metis status

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MOF evolution and operations towards Metis Data Release 2

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Metis is the coronagraph of the scientific payload of Solar Orbiter, an ESA-NASA mission which aims to study the circumsolar region and the Sun poles. Metis data and operations are managed via the Metis Operations Facility (MOF), which is built, executed and maintained by ALTEC in collaboration with INAF, funded by Italian Space Agency. The collection of functionalities and subsystems within the MOF allows both the industrial and scientific teams to plan the instrument observations, validate the observation command sequences, process the data to generate higher level data products, and finally make them available both to end-users and ESA Solar Orbiter Archive (SOAR).

Since its first deployment in 2022, 6 major versions of MOF have been released, together with an incremental expansion of the computational resources that are needed to best meet the instrument demands. The current MOF environment includes 15 virtual nodes, for a total of 96 CPU cores, about 400GB RAM and tens of TB of data storage, that can be expanded on-demand if needed.

The MOF can be divided into 5 subsystems: Data Processing, Mission Database, TM/TC Monitoring, Observation Planning (which contains the Metis Reference Model - MRM) and Infrastructure.

The Data Processing S/S runs the pipelines for the telemetry transformation and enrichment, in order to generate higher level data products up to L3. It interacts with other components of the MOF and with MOC for direct telemetry download via EDDS. The Mission Database S/S stores all the Metis telemetry and data products (including auxiliary, calibration and planning data products), and provides a set of functions to enrich product metadata during ingestion. It also makes them accessible to the scientific team via GUI or REST API. The TM/TC Monitoring is the subsystem responsible for monitoring the telemetry incoming from Metis and, partially, from the spacecraft. It is based on the ESA SCOS-2000 suite. The Observation Planning S/S integrates the MISO software (Multi Instrument Sequence Organizer) developed for creating the Command Request Files (CRF) to be delivered to the Metis Reference Model (the electronic model which provides a test bench for the generated CRF, used to validate TC sequences in IOR) and to MOC.

The MOF interfaces with several external entities: the Mission Operation Centre (MOC) at ESOC, which distributes telemetry packets and receives planned TC sequences; the Science Operations Centre (SOC) at ESAC, from which planning and auxiliary data are retrieved; the ESA SOAR, where data products of level 2 and 3 (including low-latency data) are stored for permanent archival and dissemination; the SSDC at ASI, the Italian Space Science Data Center, hosted at ASI.

In 2025, the MOF was upgraded to v6; it runs on a new and efficient infrastructure (VAMOS), and the most recent updates concerned the activation of automatic procedures to support the efficient reprocessing of data belonging to whole LTPs. This approach will be exploited to support the scientific team in the preparation of the upcoming Metis Data Release 2.

In the talk, the MOF activities and architecture will be presented in detail, as well as the interfaces with external facilities. The current state and the execution of daily and cyclic operations will be discussed, together with future perspectives.

Ray-tracing simulations of coronal structures in the context of SolO/Metis observations

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Coronal structures observed in visible light by coronagraphs are projected onto the plane of the sky due to the optically thin nature of the solar corona. Ray-tracing simulations of Thomson-scattered visible light therefore represent a powerful tool for interpreting how three-dimensional coronal features appear in coronagraphic images. In addition, the observer's vantage point plays a crucial role in shaping the observed morphology of these structures. In this work, we present ray-tracing simulations of various coronal structures, including coronal mass ejections, loops, and coronal plumes, tailored to the observational conditions of the Metis coronagraph onboard Solar Orbiter. We highlight the advantages offered by Metis' high temporal cadence for tracking the dynamical evolution of coronal features. Furthermore, we show how out-of-ecliptic observations are essential for a comprehensive characterization of the solar corona, particularly at polar latitudes.

An iterative method for determining the solar coronal temperature from Metis coronagraph observations

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Various models exist to determine the electron temperature profile $T_e(r)$ in the solar corona, which is a key parameter for understanding coronal heating and solar-wind acceleration. Among these, the recent hydrodynamic equilibrium (DYN) method, introduced by Lemaire and Stegen (2016) and Lemaire and Katsiyannis (2021), links the coronal temperature to the radial evolution of electron density and solar-wind speed. In this study, the DYN method is applied to observations from the Metis coronagraph, using electron densities derived from polarized brightness measurements and solar-wind velocities inferred through Doppler dimming diagnostics (Giordano et al., 2025). Furthermore, the combined use of the DYN model and Doppler dimming technique enables iterative studies in which an initial temperature profile is used to infer the solar-wind speed; the resulting velocity profile is then employed to compute an updated temperature, and so on.

The availability of in-situ measurements of both electron density and temperature from Solar Orbiter, Parker Solar Probe, and BepiColombo, obtained at heliocentric distances well within 1 AU, provides new constraints to the models and enables direct comparisons between model-derived temperature and velocity profiles and plasma properties measured near the Sun, offering also validation of different methods.

Invited - The PUNCH mission: Synergies with Metis

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The PUNCH mission provides new and unprecedented observations of the outer corona and inner heliosphere. However, much of the early evolution that ultimately defines the quiescent solar wind and global transients such as coronal mass ejections (CMEs) takes place in the inner corona where Metis observes, below PUNCH's field of view of approximately 6-180 solar radii. In this talk, I will first overview PUNCH current status and recent results, and then discuss synergies with Metis observations and paths for future collaboration.

Analysis of jets observed with Metis coronagraph

Authors: Angelos Michailidis¹; Giulianna Russano²; Preity Sukla Sahani²; **Costis Gontikakis**³; Vincenzo Andretta²; Ioannis Daglis⁴; Nektarios Vlahakis⁴

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Abstract: Jets are collimated plasma eruptions found on the solar surface having sizes from few arcseconds to a fraction of the solar radius. We study cases of solar jets observed with Metis coronagraph on Solar Orbiter (SO), in combination with imagers as AIA on SDO or EUV on SO along with other coronagraphs such as LASCO/C2 on SOHO and COR2 on STEREO-A.

We characterize the jets geometry calculating the solar magnetic field with the PFSS model. The three-dimension shape of the jets is calculated using triangulation methods that combine images from different satellites. The velocity of the jets is compared with calculations of the solar wind in the heliosphere.

On the relation between Lyman-alpha intensity and emission measure

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Observing eruptive prominences and other coronal structures, Metis provides the intensity maps in the hydrogen Lyman-alpha line. Based on theoretical models of the Lyman-alpha formation, we demonstrate a close correlation between the integrated line intensity and plasma emission measure where the latter depends on the effective thickness of the considered structure and its electron density. Such a correlation varies with the plasma temperature, providing a useful diagnostics tool.

Observations of fast wave trains from Solo/Metis

Authors: Federica Chiappetta¹; Giuseppe Nisticò¹; Giuseppe Prete²; **Sara Bertone**¹; Sergio Servidio²; Silvia Perri²; Vincenzo Capparelli²

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The physical mechanism responsible for the generation and propagation of quasi-periodic fast-propagating (QFP) magnetosonic wave trains in the solar corona remains poorly understood. While several events have been analyzed and modeled via numerical simulations, key questions regarding their origin and evolution remain open. We present a preliminary analysis of a coronal event occurred on 5 October 2023, in which a coronal mass ejection (CME) at the eastern limb was followed by the clear emergence of a QFP wave train. Using visible-light observations from the METIS coronagraph, covering the time interval from 19:00 UTC on 5 October 2023 to 05:00 UTC on 6 October 2023, we measure the physical parameters of the magnetosonic wave train.

Invited - From multi-decadal solar wind modelling to real-time forecasting, and on probing solar wind away from the ecliptic plane

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The solar wind is an uninterrupted flow of highly ionized plasma that streams from compact sources at or near the Sun and expands into the whole interplanetary space, being a major driver of space weather phenomena. Understanding the conditions that regulate the formation of the solar wind, its acceleration across the corona, and its transition to the heliospheric propagation regime is key to addressing many open questions in heliophysics. Physical links between observations of surface and coronal events with measurements made in-situ in the interplanetary medium are affected by the interplay between plasma flow and magnetic field, solar wind expansion and rotation, and steady and time-variable phenomena.

I will review on-going efforts in establishing connectivity across the corona and heliosphere, as well as recent advances in solar wind modelling and forecasting. I will address some of the main challenges related to the implementation and validation of connectivity and solar wind models, the delicate balance between physical accuracy and computational performance, as well as the pernicious issues that stem from the scarcity of observations made in between the two boundaries of the Sun–Earth system.

Results from data-driven global solar wind simulations that cover several solar activity cycles will be presented, highlighting relations of magnetic connectivity jumps with solar wind plasma signatures, their occurrence frequency and amplitudes at different epochs of the solar cycle, as well as the benefits of multiple of multiple points of observations (e.g L5 and off-ecliptic) for solar wind modelling.

Mapping solar wind speed with Metis observations

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The solar wind plays a central role in shaping the heliosphere and driving space weather, though the details of its origin and acceleration are full not fully understood. A major challenge lies in obtaining global measurements of the solar wind speed in the acceleration region, where remote-sensing techniques and indirect determinations are required. The Metis coronagraph on board the Solar Orbiter addresses this challenge by providing simultaneous polarized visible-light and ultraviolet H I Ly α observations, enabling the systematic derivation of solar wind speed maps via the Doppler dimming technique.

We present speed maps in the range 3.0–7.6 R_{sun} , combining Ly α intensities with electron densities derived from polarized-brightness measurements. The sensitivity of inferred speeds to key coronal model assumption (electron temperature and kinetic neutral hydrogen temperature, as well as and helium abundance) is qualitatively assessed.

The results confirm the bimodal structure of solar wind as expected near solar minimum. The slow wind (100–200 km s⁻¹) confined to the equatorial streamer belt and fast wind (250–400 km s⁻¹) originates from polar coronal holes, separated by sharp transitions at mid-latitudes. Variations in coronal assumptions are found significantly impact the retrieved speeds, emphasizing the need for tighter constraints on coronal plasma conditions.

To place these results in a broader temporal and spatial context of this analysis, the same approach is applied to daily ultraviolet intensity maps reconstructed from UVCS/SOHO observations, combined with LASCO/SOHO white-light data, covering most of Solar Cycle 23. This extended dataset probes the solar wind acceleration region between 1.5 and 4.0 R_{sun} , providing critical context for the interpretation of current Solar Orbiter measurements.

This work establishes Metis as a powerful tool for systematic, cycle-long mapping of the solar wind and provides valuable constraints for models of coronal heating and wind acceleration. Future perihelion observations will further refine these results.

Probing solar wind origins and coronal parameters through PSP- SolO quadrature and corotation studies

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The quadrature and corotation configurations between Parker Solar Probe (PSP) and Solar Orbiter (SolO) provide an exceptional opportunity to study the coupling between the solar corona and the nascent solar wind. We analyze coordinated remote-sensing (RS) and in-situ observations obtained during periods when PSP corotated with the Sun while SolO viewed the same source regions from near-quadrature vantage points. This unique geometry enables simultaneous sampling of coronal structures and their heliospheric extensions. Using the SolO Metis coronagraph's high-resolution ultraviolet (UV) and polarized visible light (VL) diagnostics, we derive the coronal electron density, proton density, and magnetic topology. Meanwhile, PSP in-situ data constrain plasma and field properties at several solar radii. Additionally, by combining these datasets through the Doppler Dimming Tool (DDT), we reconstruct the plane of the sky distribution of solar wind speed and identify the coronal origins of distinct solar wind streams and the cause of solar wind acceleration.

Invited - Mesoscale solar wind density structures created by interchange reconnection in the solar corona

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Decades of density measurements made throughout the inner heliosphere show that the solar wind is often comprised of mesoscale structures. One type of mesoscale solar wind structure manifests as periodic trains of density enhancements, with scales of 0.2 mHz (~90 minutes) to 5 mHz (~ a few minutes). Periodic density structures directly drive oscillations in Earth's magnetosphere as a forced-breathing, wherein each density structure engulfs the magnetosphere, squeezing it as it passes. This interaction drives ultralow frequency waves in the magnetosphere and periodic dynamics in Earth's radiation belts. Additionally, periodic density structures are important diagnostics of solar wind formation. Studies of composition during these periodic density structures demonstrates that they are created at the Sun as the solar wind is formed. White light imaging data of the corona and young solar wind have shown that the source of the longest/largest of these trains of periodic density structures is likely helmet streamers. A possible source of the higher-frequency periodic density structures is interchange reconnection along Separatrix-web arcs in the solar corona, periodically driven by jetlets and/or transverse Alfvénic fluctuation.

Solar Orbiter coordinated observation of coronal density fluctuations: An overview

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The backbone of Solar Orbiter coordinated observations is constituted by the so-called SOOPs (Solar Orbiter Observing Programs), which are designed to address specific science objectives of the mission.

This contribution focuses on the SOOP identified as “R_FULL_HRES_HCAD_Density-Fluctuations”, which has the primary objective of studying density fluctuations in the middle or extended corona. This SOOP has been run regularly since the first orbit of the nominal mission in March 2022. The program typically involves high-cadence observations with the Metis coronagraph and the Full Sun Imager (FSI) of the Extreme Ultraviolet Imager (EUI). In specific instances, the SPICE spectrograph and the two High Resolution Imagers (HRI) of EUI have also been employed to provide complementary data closer to the solar surface.

In this work, we present an overview of the observations carried out within the framework of this SOOP. Furthermore, we illustrate highlights of the main results obtained.

Magnetohydrodynamic wave modelling in the solar wind and their observations with Metis

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Magnetohydrodynamic (MHD) waves are ubiquitous in the solar atmosphere and are key in many models for seismological or energy conversion processes. Metis has observed such waves too thanks to its unprecedented cadence. Using MHD simulations, we study wave propagation in a helmet streamer. Our model includes important physics such as spherical expansion, gravitational stratification, thermal conduction, radiative cooling, and a background wind. The magnetic field configuration associated with a helmet streamer not only provides opportunities for wave dissipation in open and closed field regions, but also at the interface of the two. In all cases, wave dissipation can happen via phase mixing, which, in conjunction with ponderomotive forces due to non-linear waves, can perturb the local density and temperature.

We compare the density variations of our model with observations of Metis in order to diagnose the mechanisms that lead to the observed propagation of waves in streamers and pseudostreamers and into the solar wind.

Analysing geoeffective events using Metis data and physics-based empirical models

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The Metis Coronagraph onboard Solar Orbiter observes simultaneously in Visible (VL) band between 580 and 640 nm and Ultraviolet (UV) band at 121.6 nm. It observes at a high spatial and temporal resolution, thus, allowing a comprehensive analysis of solar events.

In particular, the Metis team is creating a database of solar eruptive events observed in both the VL and UV channels. The CME Catalogue now has more than three years worth of data, from November 2020 to December 2023 and is actively being updated.

We track the events that could be geoeffective, and could therefore be linked with various space weather phenomena. Here, we describe the work being done in identifying these events from the Metis CME catalog. The first step is to identify events that can be potentially geoeffective. Then, the identification is refined by applying the triangulation method where the Coronal Mass Ejections (CMEs) are fitted using the Graduated Cylindrical Shell (GCS) model. This results in accurate measurement of the position, speed and direction of propagation of the CMEs. For this purpose, along with the VL Channel data from Metis, white light coronagraph data from LASCO C2 and STEREO COR2A were also used.

Furthermore, we employ the physics based empirical models like Drag-Based Model (DBM) and Drag-Based Ensemble Model (DBEM), WSA-Enlil and EUHFORIA to predict the times of arrival on Earth. In this work, I will present a complete analysis for some Metis observed geoeffective events identified from the catalogue (including some work in progress) while comparing the predicted results with the in-situ measurements at Earth (and other S/Cs). Finally, on the basis of these comparisons made, we plan to assess the relative forecasting capabilities of the propagation models employed.

Invited - From flares to the corona: Python tools for cross instrument connectivity

Author: Laura Hayes¹

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A key challenge for maximizing Solar Orbiter science return is building an interoperable Python ecosystem for working with mission data, enabling rapid and reliable connections between observations from different instruments. Cross-instrument event catalogues are central to this, but creating catalogues that are accurate and usable by the wider community requires consistent event definitions, robust metadata, and reproducible workflows.

In this talk I will use solar flares as observed by STIX as a practical example for cross instrument catalogue development, showing how hard-X ray and EUV flare signatures can be combined with contextual observations to define key event parameters such as timing, localization, and observational coverage. I will highlight how flare-based catalogues can also support connections to coronal observations, including CME and off limb evolution seen by Metis, and the requirements for catalogues that enable both targeted case studies and statistical analyses. I will highlight how Python based tools, including SunPy, and community coordination can enable scalable workflows for cross instrument studies, from event discovery and data access through to catalogue building and analysis.

Python tools for cosmic-ray and solar particle analysis with Metis and EPD/HET data. Preliminary results on out-of-the-ecliptic observations

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Data provided by the instruments placed on board Solar Orbiter are pivotal for several different, yet intertwined, applications. For instance, observations from the EPD/HET instrument are needed to run Monte Carlo simulations to reproduce the tracks in the Metis cosmic-ray matrices and for comparison with results of the visual analysis.

To make visual analysis tasks easier and faster, our group has designed dedicated software applications. First, we have developed the SEPPEL tool, devoted to the detection of solar energetic particle (SEP) events noticeable from the EPD/HET observation time series. SEPPEL provides a suite of functionalities aimed at generating customizable plots of the EPD/HET protons, with the possibility to save the generated images on the local disk or in the application memory for further elaborations. Second, we have built the REBECCA tool upon our previous experience on the

visual analysis of the Metis cosmic-ray matrices. REBECCA enables the analysis of one or more complete matrices, unfeasible for human analysts, in just a few seconds. A set of utilities is also present to complement the automated analysis with human feedback and to average results over multiple elaborations. For the first five years of the mission, cosmic-ray and SEP events were studied near the ecliptic. In 2025 the Solar Orbiter orbit has begun to tilt with respect to the ecliptic. We have compared the preliminary results of the Metis cosmic-ray matrix observations out of the ecliptic at $\pm 16^\circ$ with the most similar conditions of solar activity obtained when the spacecraft was orbiting the Sun near the ecliptic. This preliminary analysis appears consistent with our previous observations, but the different position of the spacecraft with respect to the interplanetary magnetic field lines is expected to affect the particle interactions deeply into the spacecraft. Details on the analysis will be presented at the conference.

Investigating the evolution of erupting prominences uninterruptedly using EUI FSI + Metis mosaics

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Understanding how erupting prominences evolve as they rise through the middle corona is essential for constraining the early phases of coronal mass ejections (CMEs).

This study aims to investigate the evolution of erupting prominences across the transition from the inner to the middle corona by combining observations from EUI/FSI and Metis aboard Solar Orbiter. The unprecedented characteristics of these instruments—such as the large field of view of a coronal EUV imager, the overlap between their FOVs, and the high-cadence sequences acquired during Remote Sensing Windows—enable the construction of continuous mosaics that trace prominence dynamics and morphology seamlessly from their onset in the low corona up to several solar radii. As part of this project, we are developing EUIMET, a dedicated tool to generate EUI FSI + Metis mosaics from calibrated data, allowing users to customize enhancement techniques and opacity levels to optimize the visibility of key coronal features.

We apply this method to the spectacular polar crown eruption of the 20 October 2023, jointly observed by both instruments, to perform an in-depth morphological and kinematic characterization, through triangulation and time-distance analyses. This case study serves as a proof of concept for future systematic investigations of eruptive prominences observed simultaneously in the EUV, UV, and WL regimes.

By providing a unified view of prominence evolution across the middle corona, this work aims to improve our understanding of CME initiation and propagation processes. The developed mosaic tool and data products will be made publicly available to support the solar physics community.

Study of an erupting prominence combining Solar Orbiter / Metis and ASO-S/LST & SDI observations in the VL and UV Lyman-alpha

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Studying the evolution of the energy budget involved in solar eruptions is central, particularly to understanding their early stages, but also for the subsequent interplanetary expansion. For this purpose, it is important to quantify the

thermal energy evolution of erupting plasma, compare it with the expected adiabatic cooling, and determine at least approximately how energy is partitioned among its kinetic, potential, and thermal components. This can be done by combining observations acquired in different spectral bands and possibly from different observation points.

Here we report on a prominence eruption that was observed simultaneously by the multichannel Metis Coronagraph onboard the Solar Orbiter mission, and by the Lyman-alpha Solar Telescope (LST) onboard the Advanced Space-based Solar Observatory (ASO-S) from different perspectives. The prominence appeared as a very bright and elongated arch propagating southward in Metis UV Lyman-alpha images, but it is much weaker in Metis visible light (VL) images. The Solar Disk Imager (SDI) of LST observes the prominence lifting from the southwest solar limb, with the south leg fixed onto the Sun as it expands.

The multichannel observations of Metis enable us to measure the electron density, the mass, and the velocity of the prominence. On the other hand, by taking advantage of Lyman-alpha observations, we applied a new approach independent of the UV calibration to estimate the temperature evolution of two segments of the prominence. The results obtained are in good agreement with what can be measured with the standard technique based on the evolution of the total Lyman-alpha intensity, considering both the radiative and collisional components. Resulting measurements of the excess thermal energy suggest that a significant heating is going on during the eruption.

Thermodynamic evolution of an expanding flux rope as observed by the Metis multi-channel coronagraph

Author: Emanuele Amato¹

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As Coronal Mass Ejections (CMEs) propagate through the corona, they should cool adiabatically as an almost isolated plasma bubble, yet observations indicate that heating processes can offset this cooling and keep temperatures nearly constant (Sheoran 2023) or increasing (Bemporad et al. 2007; Bemporad 2022). Although several heating mechanisms have been proposed for individual events (e.g. Akmal et al. 2001; Ciaravella et al. 2003; Lee et al. 2009; Landi et al. 2010; Murphy et al. 2011), it remains an open question which mechanisms dominate in general and how much total heating CMEs experience. To study the evolution of plasma temperatures in the expansion phases of a CME, classical coronagraphic images of broadband visible light (VL) from Thomson scattering are not sufficient, and narrowband observations of radiation emitted at specific wavelengths are also needed. On November 10, 2021, the Metis multichannel coronagraph onboard Solar Orbiter observed the expansion of a flux-rope associated with a slow limb CME (deprojected speed 155 km/s). The observations were acquired with both the VL and UV Lyman-alpha channels, with the field-of-view covering the heliocentric distances between 5.3 and 9.6 solar radii. The eruption manifested as a faint, bubble-like structure, slightly brighter than the surrounding ambient corona. Image analysis exploited the direct UV/VL ratio Doppler-dimming technique (Bemporad et al. 2021), which was used to test a new analysis technique that allowed us to iteratively determine the best flux-rope temperature in each of the image pairs. First results will be presented and discussed here in comparison with the expected adiabatic cooling curve, and typical temperature profiles for the ambient corona.

Asymmetric eruption and non-radial propagation of a solar filament

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While asymmetric eruptions and nonradial propagation of solar filaments are typically attributed to inhomogeneous overlying magnetic fields, the role of the filaments' intrinsic asymmetry remains underexplored. In this work, we analyze the evolution of an intermediate-type filament from its activation and asymmetric eruption to its propagation

alongside an associated coronal mass ejection (CME). Contrary to expectations, magnetic cancellation and a lower critical height for torus instability were identified at the filament's confined leg. Intermittent bursts originating from the magnetic cancellation region supplied hot plasma to the filament and drove unidirectional flows toward the eruptive leg. Alongside these bursts, $H\alpha$ Doppler images clearly revealed enhanced filament asymmetry: prior to eruption, the eruptive leg exhibited a larger cross-section, more dynamic flows, and persistent blueshift. During the propagation, the erupting filament initially had a larger inclination angle than the CME, which was consistent with the asymmetric eruption behavior; the filament's inclination gradually aligned with that of the CME as the event progressed. Finally, we discuss the combined effects of the overlying magnetic field and the filament's intrinsic magnetic field on both the eruption and subsequent propagation.

Invited: Observing the solar corona by the ASPIICS coronagraph aboard the Proba-3 formation-flying mission

Author: Andrei Zhukov¹

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Proba-3 is an ESA mission dedicated to the in-flight demonstration of precise formation flying techniques and technologies, launched on 5 December 2024. The Proba-3 mission consists of two small satellites in a highly elliptical orbit around the Earth. During observation campaigns around the orbit apogee, the two satellites fly in a precise formation, producing a very long baseline solar coronagraph called ASPIICS (Association of Spacecraft for Polarimetric and Imaging Investigation of the Corona of the Sun). One spacecraft carries the optical telescope, and the second spacecraft carries the external occulter of the coronagraph. The inter-satellite distance of around 144 m allows observing the inner corona in eclipse-like conditions, i.e. close to the solar limb and with very low straylight. The first results of ASPIICS will be presented, and synergies with the Metis coronagraph aboard the Solar Orbiter mission will be discussed.

First Metis-ASPIICS coordinated observations

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Co-authors: Andrei Zhukov²; Emanuele Amato¹; Laurent Dolla²; Luca Zangrilli¹; Lucia Abbo¹; Marco Romoli³; Riccardo Chiartano¹; Roberto Susino¹; Sergei Shestov²; Silvio Matteo Giordano¹

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The Earth-orbiting ASPIICS/Proba-3 and the Sun-orbiting Metis/Solar Orbiter provide a changing, multi-point view of the solar corona, depending on the relative Earth-to-Solar Orbiter positions on- and out-of-the-ecliptic plane. The first Metis-ASPIICS coordinated observations took place in 2025, during the Solar Orbiter superior conjunction in August, its quadrature in September and inferior conjunctions in October.

This presentation will illustrate the results of these first Metis-ASPIICS joint campaigns in conjunction also with the LASCO coronagraphs onboard the ESA SOHO mission in L1. This will offer the opportunity to present and discuss suggestions and requirements for proposed future missions (e.g., Solaris, DarkSun, ESA Vigil-L5, KASA-L4).

Detection of downflows with Metis and ASPIICS observations

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We have analyzed high temporal frequency visible light observations acquired by Metis coronagraph on Solar Orbiter during the perihelia on October 2022, April 2023 and September 2024.

In particular, we focused on series of total and polarized Brightness observations lasting for 40 min up to few hours,

acquired with a cadence of 20 s and 60 s. The field of view of the observations ranges from 1.7 to 3.5 solar radii. We have found in these data sets several examples of inflows detected as collapsing loops and density inhomogeneities. We have noticed that this kind of features are observed mainly along the streamer axis and they are not observed in pseudo-streamers.

Similar features have been detected by ASPIICS on PROBA3 from the limb to few solar radii, allowing the study of the dynamics of the corona with a continuous coverage of the field of view.

Coronal polarized brightness measured by Solar Orbiter/Metis within solar cycle 25

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Metis, the coronagraph on board Solar Orbiter, is an externally occulted instrument with a field of view (FOV) spanning 1.7°–3.4°, which, over the course of a typical spacecraft orbit, corresponds to heliocentric distances from 1.7 to about 10 solar radii. Metis operates with two radiometric channels: one measures coronal emission in a narrow ultraviolet (UV) band centered on the H I Lyman- α line, while the other records broadband visible light (VL) in linearly polarized intensity.

In this work, we present a statistical analysis of the linearly polarized brightness (pB) measured over Solar Cycle 25 as a function of heliocentric height and polar angle, based on the updated Metis calibration released with Data Release 2. We also compare these results with published pB values obtained from eclipse observations, as well as from both ground-based and space-borne coronagraphs.

Narrowband observations with the PROBA-3/ASPIICS coronagraph

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In addition to the polarised and unpolarised wideband filters (white light continuum), The PROBA-3/ASPIICS coronagraph has two narrowband filters (NBF) centered on specific spectral lines: Fe XIV (530.45 nm; FWHM 0.5 nm; imaging the corona around 1.5-2 MK) and He I D3 (587.72 nm; FWHM 2 nm; imaging prominences). Because the wideband filter is quasi-free of any coronal emission line, it is possible to separate, in the NBF channels, the spectral line and continuum contributions. We will present the most recent calibration of the NBF and the analysis of the images after continuum subtraction.

Diffraction in ASPIICS: observations and modeling

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ASPIICS is a 144m baseline coronagraph onboard the Proba-3 mission, designed to perform regular observations of the solar corona in visible light over a field of view (FOV) from 1.1 to $3R_{Sun}$. Despite very low minimal FOV, the amount of the diffracted light reaching the ASPIICS detector is extremely small and is not detectable in routine coronal images. However, this diffracted light becomes observable during dedicated calibration campaigns with off-pointings of the telescope. In this work, we analyze available observations and compare the measured diffracted light with the numerical model. The observed data reproduce all major features predicted by the model, with absolute intensity levels agreeing within approximately 50%. We discuss possible origin of the remaining discrepancy, and applications of the model to other existing or future space coronagraphs.

Preliminary characterization of the Metis ultraviolet point spread function

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Metis was designed to capture images of the Solar Corona in visible (VL, 580-640 nm) and ultraviolet (UV, Ly-alpha, 121.6 nm) wavelengths. This work focuses on a preliminary characterization of the instrument's optical performance in the UV channel through Point Spread Function (PSF) analysis. Our approach involves the study of stellar sources detected in the Metis UV Field of View (FOV). Through comparison with theoretical predictions from Zemax optical models, we evaluate the actual in-flight PSF profile and investigate potential deviations from expected behavior. This analysis allows us to establish a first assessment of the UV channel's optical quality and its response variations across the detector plane.

The preliminary findings contribute to understanding the operational characteristics of the Metis UV coronagraph in the space environment, offering initial validation of the instrument's imaging capabilities at Ly-alpha wavelengths and laying groundwork for future detailed performance studies.

Optional Session

Metis Calibration Issues (coord. by M. Romoli and S. Fineschi)