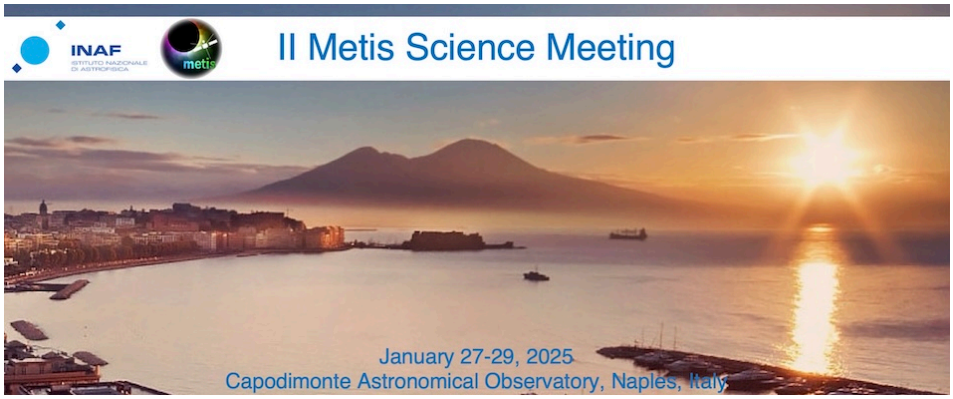
2nd Metis Science Meeting



Report of Contributions

https://indico.ict.inaf.it/e/3034

Contribution ID: **3** Type: **not specified**

Metis status and science so far

Metis coronagraph on board Solar Orbiter images the extended solar corona in VL and UV. Metis performance after 5 years of operations will be presented with a brief summary of the science achieved so far and the data availability.

Primary author: Prof. ROMOLI, Marco (Università di Firenze)

Presenter: Prof. ROMOLI, Marco (Università di Firenze)

Session Classification: Metis Science

Contribution ID: **4** Type: **not specified**

SWA status and science so far

The Solar Orbiter mission represents an unprecedented opportunity to understand the fundamental link between the magnetised solar atmosphere and the dynamics of the solar wind, thanks to its unique payload consisting of both remote sensing and in situ instruments.
Within this framework, the Solar Wind Analyzer (SWA) is a key in situ instrument to characterize the near-Sun environment. In particular, SWA will contribute to provide significant advances in our understanding of the mechanisms accelerating and heating the solar wind, driving eruptions and other transient phenomena on the Sun, and controlling the injection, acceleration, and transport of the energetic particles in the heliosphere.
This presentation will provide an overview of the SWA plasma suite, its status, the scientific highlights and synergies.

Presenter: D'AMICIS, Raffaella (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Metis Science

Contribution ID: **5** Type: **not specified**

The Coupling of the Closed and Open Corona

In standard models of the solar corona, the plasma dynamics in closed coronal loops is assumed to have a negligible effect on the open field. The underlying assumption is that the low beta of the closed corona implies that any plasma pressure variations result in small perturbations in the magnetic field. This assumption breaks down, however, at the tops of helmet streamers where the field becomes open as a result of the gas pressure. At streamer tops, fluctuations in the plasma pressure are likely to drive the opening and closing of flux. This may be the process responsible for the quasi-periodic density enhancements that are commonly observed in coronagraph images of the wind from streamer top regions. We propose that the process of thermal nonequilibrium (TNE) may be driving streamer tops and producing the quasi-periodic enhancements. The physical origin of TNE is that if the heating in a coronal loop is spatially localized near the chromospheric footpoints on a scale that is small compared to the loop height, then no static or steady equilibrium is possible. As a result, the loop undergoes a quasi-periodic cycle of heating and catastrophic cooling, implying strong plasma pressure variability. We present 2.5D MHD simulations of TNE in a streamer field configuration. We find that TNE does, in fact, drive magnetic field dynamics at the streamer apex, which corresponds to the base of the heliospheric current sheet. We discuss the role of TNE in determining the reconnection that occurs at the current sheet. Furthermore, we discuss the implications for observations of the corona and wind, in particular, for Metis. This work was supported by the NASA LWS Program.

Primary author: ANTIOCHOS, Spiro (University of Michigan)

Co-author: MACNEICE, P. J. (NASA/GSFC)

Presenter: ANTIOCHOS, Spiro (University of Michigan)

Session Classification: Metis Science

Contribution ID: **6** Type: **not specified**

Preliminary Analysis of Recurrent and Confined Plasma Emission Observed by Metis on 5–6 October 2023

On 5–6 October 2023, Metis captured high-cadence images of a sequence of coronal plasma emissions. These emissions, constrained by an overlying magnetic field, do not propagate beyond 3 solar radii and appear to fall back onto the Sun. This presentation will describe the available dataset, showcase preliminary analyses, and provide an overview of the context in which these events occur, aiming to foster discussion on potential interpretations.

Primary author: ROMANO, Paolo (Istituto Nazionale di Astrofisica (INAF))

Co-author: ANDRETTA, Vincenzo (Istituto Nazionale di Astrofisica (INAF))

Presenter: ROMANO, Paolo (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Metis Science

Contribution ID: **7** Type: **not specified**

CME plasma diagnostics using Metis coronagraph

We have derived the physical parameters of a bright eruptive prominence detected in the core of a CME by using simultaneous SolO/Metis hydrogen Lα and VL images for the whole FoV. Our analysis is focused on the event observed on April 25-26, 2021. With triangulation method the deprojected height and velocity of the structure was determined. By analyzing the VL polarization, we have estimated the contribution of the He-D_3 line to the VL channel. We developed a diagnostic tool based on a 2D non-LTE radiative transfer code which can be used for optically thin and thick fast-moving structures. By analyzing the observed Lα intensity and derived electron column density we can estimate the electron density and the effective thickness of the prominence plasma at a given uniform temperature. The temperature was constrained by our numerical simulations.

Primary author: JEJČIČ, Sonja (University of Ljubljana, FMF)

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Presenter: JEJČIČ, Sonja (University of Ljubljana, FMF)

Session Classification: Metis Science

Contribution ID: **8** Type: **not specified**

High cadence and high resolution observation of a CME observed by Solar Orbiter Metis Coronagraph in October 2022

During the October 2022 perihelion, the Metis coronagraph on-board Solar Obiter captured an exceptionally large coronal mass ejection (CME) during a dedicated observation program. This event was recorded with high temporal (cadence 20 s) and spatial (4.5x10^3 km/px) resolution, within a field of view extending from 2 to 3.1 solar radii at a distance of 0.3 AU from the Sun. Detailed investigation from time-averaged running difference imaging reveals detailed structural features of these eruptions with unprecedented resolution. These observations include upward and downward flows of material as well as the presence of coronal wavefronts that appear not to interact with the CME itself, prompting speculation about their origin and nature. The investigation of these wavefronts is particularly significant, as it offers new insights into the dynamic processes within the solar corona, potentially shedding light on previously unknown mechanisms of energy transfer and wave propagation in the Sun's atmosphere. In this study, we present a comprehensive analysis of the eruptive event, providing significant findings regarding its kinematic properties, temporal evolution and the outflow velocity within the expanding solar corona. Additionally, the observations are complemented by data from radio instruments and other space-based coronagraphs and disk imagers, enabling the complete tracking of the event from its initiation in the low corona to its expansion up to higher layers of the solar atmosphere.

Primary author: RUSSANO, Giuliana (Istituto Nazionale di Astrofisica (INAF))

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Presenter: RUSSANO, Giuliana (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Metis Science

Contribution ID: **9** Type: **not specified**

Unifying the Physical Understanding of CMEs through Remote Sensing Observations in the PSP/SolO Era

Recent high-resolution observations from the Parker Solar Probe and Solar Orbiter reveal complex variations in CME structures, posing significant challenges to existing models. With the ability to directly compare simultaneous remote imaging and in-situ measurements, we can now probe CME internal structures in unprecedented detail. These advances raise questions about whether our current understanding truly captures the observed dynamics or if a fundamental rethinking of CME structure and evolution is needed. In practice, despite progress, substantial gaps remain between models, imaging, and in-situ interpretations that must be addressed to achieve a cohesive understanding of CME structures from the Sun through the heliosphere.

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Presenter: LIBERATORE, Alessandro (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Metis Science

Contribution ID: **10** Type: **not specified**

Forward models of white light emission from MHD simulations of reconnection outflows and coronal mass ejections

Metis's capability to observe at high time cadence and resolution mass ejections into the low solar wind offers exciting new perspectives on how these features evolve and are accelerated. High resolution magnetohydrodynamic simulations can play an important role in helping interpret these observations. In recent years I've conducted high resolution MHD simulations with the ARMS code of bursty interchange reconnection and coronal jets as well as streamer blow out and pseudostreamer CMEs. In parallel, a new forward modelling code has been developed (Lynch et al. 24, submitted) for ARMS simulation output. Recently, using this code (Romano et al., in prep) quasi-periodic dense outflows in my bursty interchange reconnection simulation were shown to match closely outflows following a narrow jet-like CME observed by Metis. Here I'll give an overview of some of my other simulation results and their forward modelled white light signatures as a starting point for further potential comparisons to events observed by Metis.

Primary author: WYPER, Peter

Presenter: WYPER, Peter

Session Classification: Metis Science

Contribution ID: **11** Type: **not specified**

Reconstructing the interplanetary propagation of the September 5, 2022 ICME event with a data-driven MHD simulation

On September 5, 2022, a Coronal Mass Ejection (CME) was multiply observed by coronagraphs on board the STEREO and SOHO spacecraft, and by the WISPR coronagraph on board the Parker Solar Probe (PSP). A few hours later, the plasma and magnetic field of the perturbation were measured in-situ by PSP at 0.07 AU and by Solar Orbiter at 0.7 AU. This event offers therefore a unique set of constraints for physical modeling. Here, we present a numerical MHD simulation of the interplanetary CME propagation in the heliosphere. The Parker Spiral is accurately reconstructed from 5 solar radii to 1 AU using RIMAP, a data-driven hybrid analytical-numerical technique. The magnetic field and solar wind background conditions are reconstructed from PSP in-situ measurements before and after the CME encounter. From the conditions ballistically remapped at 5 solar radii, the whole Parker spiral is then reproduced by solving numerically the MHD equations with the PLUTO code. The CME enters the RIMAP-reconstructed spiral at 5 solar radii as a magnetic flux-rope adapted from the Titov-Démoulin model, with parameters constrained from coronagraphic observations. The MHD simulation describes the propagation of the CME out to 1 AU. An artificial tracer allows us to track the CME plasma. The highly structured and realistic reconstruction of RIMAP allows us to draw conclusions on the interaction between the CME and the Parker Spiral with a good degree of accuracy. We compare the properties of the CME-driven shock to the in-situ measurements of PSP and Solar Orbiter, and, in the light of the few free parameters, discuss the validity and limitations of the model and also how this event would have been measured by a spacecraft at 1 AU.

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Presenter: BIONDO, Ruggero (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Metis Science

Contribution ID: **12** Type: **not specified**

Metis Observations of Geoeffective Solar Events

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 also observes at high spatial and temporal resolution, thus, allowing a comprehensive interpretation 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 Database now has more than two years worth of data from November 2020 to December 2022. An important subset of these events could be geoeffective, thus linking these with various space weather phenomena. The identification of these events from the Metis data is an additional work done alongside building the database.The approach we adopted is described in this talk. In particular, we apply the triangulation method on the potential geoeffective events to determine their accurate position, velocity, and direction of propagation for further analysis. For this purpose, along with the Metis Data, LASCO C2 and STEREO COR2 data were also used. Furthermore, we estimate the transit times to Earth for these events using sophisticated models like WSA-ENLIL and Drag-Based Model (DBM). Further analysis using the space weather forecast targeted inner heliospheric model called EUHFORIA is done which takes geoeffectiveness of the chosen events into context, allowing direct comparison with the observed Dst indices. In this talk, I will present an overview of the Metis catalogue subset focusing on notable geoeffective events from 2022.

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Presenter: Ms SAHANI, Preity Sukla (Istituto Nazionale di Astrofisica (INAF), Capodimonte)

Session Classification: Metis Science

Contribution ID: **13** Type: **not specified**

Applying Supervised Learning Methods for Metis Data Validation

We present the application of supervised learning methods to classify Metis VL and UV images during data validation activities. By examining Metis data collected over the first three years of the Nominal Phase of the Solar Orbiter mission, we labeled various features present in the images. This labeled dataset was then used to train a Support Vector Classification (SVC) model and to predict image categories. To evaluate the performance of the trained model, we compared the predicted labels with the actual ones and assessed the model's accuracy using a confusion matrix.

Primary author: BURTOVOI, Aleksandr (Istituto Nazionale di Astrofisica (INAF))

Co-author: Prof. ROMOLI, Marco (Università di Firenze)

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Session Classification: Metis Science

Contribution ID: **14** Type: **not specified**

Detection and classification of comet-like objects in Metis coronagraph images using deep learning

The detection of small objects, such as sungrazing comets or asteroids, passing in the field of view of solar coronagraphs, remains an underexplored field of research. This gap presents an opportunity to leverage advanced deep learning methodologies for detecting these objects in the images of Metis, the multi-wavelength coronagraph aboard the Solar Orbiter mission. Metis offers imaging capabilities in both UV and visible light spectra. Our proposed methodology to detect and classify the objects begins with the analysis of Level 0 (L0) non calibrated images. In cases where L0 images present challenges, we propose an alternative approach using Level 2 (L2) calibrated images to enhance detection reliability. To improve detection and classification, the methodology will incorporate temporal analysis of sequential images, leveraging motion patterns to identify and track objects like comets or asteroids. Additionally, advanced machine learning architectures, including Convolutional Neural Networks and transformer-based models, will be employed for efficient and accurate object detection. Finally, an automated and scalable framework will be developed to process vast datasets, in view of the feasibility of real-time analysis. This comprehensive approach aims to facilitate the discovery of previously undetected astronomical objects, like sungrazing comets or asteroids, transiting in coronagraph images.

Primary author: MEZA ANZULES, Stefano Rafael

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Presenter: MOUALLA, Lama (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Metis Science

Contribution ID: **15** Type: **not specified**

Monitoring the evolution of intense solar energetic particle events with the Solar Orbiter EPD-HET and Metis instruments

Galactic cosmic rays and solar particles above 70 MeV/n are energetic enough to pass through or interact deeply within the Solar Orbiter spacecraft. Particle tracks in the Metis visible light images are studied with a visual analysis of the cosmic-ray matrices. The results of this analysis are compared to Monte Carlo simulations carried out with the use of EPD/HET proton data gathered outside the satellite. The solar energetic particle events started on July 24, 2023 and February 9, 2024 have been considered in particular. Data availability for both EPD/HET and Metis instruments has constrained this choice among the most long and intense events observed during the present solar maximum.

Primary author: Prof. GRIMANI, Catia (University of Urbino Carlo Bo and INFN Florence)

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Presenter: Prof. GRIMANI, Catia (University of Urbino Carlo Bo and INFN Florence)

Session Classification: Metis Science

Contribution ID: **16** Type: **not specified**

Search in Metis images for structures related with energetic particle events

3He-rich particle events were observed during the March 2022 perihelion flyby of Solar Orbiter, (Mason et al 2022, Solar Orbiter nugget~12). Some of these events were found to be related with a large jet emerging from Active Region NOAA 12957, visible on disk center. More energetic particle events were recorded on March the 6 and 18 to 19 by in-situ instruments (Mason et al 2022). In this work we search for possible traces of these events in Metis images. This effort is combined with magnetic field extrapolation using a PFSS potential field approximation, along with codes using other magnetic extrapolation approximations.

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Session Classification: Metis Science

Contribution ID: **17** Type: **not specified**

Helium emission in eruptive prominences

Observations of eruptive prominences by VL channel of Metis and by D3 channel of ASPIICS provide the HeI D3 line intensity. Moreover, EUI/FSI provides the intensity of HeII 30.4 nm. Understanding the formation of these lines under the conditions of eruptive prominences represents a key task for deducing the plasma parameters and magnetic field topology. We will present a new multilevel non-LTE radiative-transfer code capable of synthesising the line intensities emergent from highly dynamical eruptive prominences. A preliminary comparison with observations will be shown.

Primary author: HEINZEL, Petr (Czech Academy of Sciences)

Co-authors: Prof. BERLICKI, Arkadiusz (Centre of Excellence - Solar and Stellar Activity, University of Wroclaw, Poland); JEJČIČ, Sonja (University of Ljubljana, FMF)

Presenter: HEINZEL, Petr (Czech Academy of Sciences)

Session Classification: Metis Science

Contribution ID: **18** Type: **not specified**

Observations of Polar Plumes with Metis Coronagraph

The Metis coronagraph takes observations with high cadence of the solar corona, allowing an unprecedented time resolution in the study of coronal structures, in particular that of polar plumes in visible light. Moreover, the possibility of freezing the vantage point during periods of corotation, enables to follow the evolution of single plumes, virtually for days. I will discuss the analysis procedure and preliminary results.

Primary author: ZANGRILLI, Luca (Istituto Nazionale di Astrofisica (INAF))

Presenter: ZANGRILLI, Luca (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Metis Science

Contribution ID: **19** Type: **not specified**

Compact downflows in open-field regions observed by Metis during the fourth Solar Orbiter perihelion

The fourth perihelion of the Solar Orbiter nominal mission occurred on October 7h, 2023. During the 12-days window around the closest approach (0.29 au), Metis carried out a series of observations at medium and high cadence: from 120 s in pB sequences, down to 20 s in total brightness runs. During the high-cadence observations carried out on October 5th 2023, Metis captured numerous features apparently moving downwards in a region of the corona above a coronal hole visible on the N-E quadrant of the solar disk. The measured downwards speeds of these features are on average higher than the more commonly observed downflows seen in streamer regions (speeds larger than 100, 150 km/s, compared to the few tens of km/s observed in a nearby streamer). A closer inspection reveals that these features are characterized by a front brighter than the surrounding corona, sometimes with an "inverted-loop" shape, followed by a depression in brightness. We present these observation and discuss possible interpretations. An intriguing possibility is that the observed phenomena are the manifestation of Thermal Non-Equilibrium (TNE) cycles occurring in the context of a transonic solar wind. Such TNE cycles have been observed and simulated so far only for the closed corona and chromosphere. However, recent calculation (Scott et al., ApJ in press) have shown that such TNE cycles can occur in the solar wind, although at much lower heights than those observed by Metis. Further modelling studies are needed in order to determine whether TNE can occur at the heights of the Metis observations and, if not, alternative processes that can account for these observations.

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Presenter: ANDRETTA, Vincenzo (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Metis Science - Short communications

Contribution ID: **20** Type: **not specified**

Can we extract F-corona from Metis data?

The photospheric radiation scattered by dust particles in the vicinity of the Sun is known as the F-corona. The brightness of the F-corona dominates over the K-corona at distances greater than approximately 3 solar radii. For coronagraphs orbiting in the ecliptic plane at similar distances from the Sun, such as Stereo/Secchi and SOHO/LASCO, deriving the F-corona is relatively straightforward due to its low spatial and temporal variability. In contrast, Metis has an elliptical orbit with a higher inclination relative to the ecliptic, and its observations lack regularity. By employing a dust scattering model and utilizing unpolarized coronal images (Metis tB), we show how to derive the F-corona. This approach is valuable for characterizing the properties of the F-corona at short heliocentric distances and at higher latitudes above the ecliptic.

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Presenter: Prof. ROMOLI, Marco (Università di Firenze)

Session Classification: Metis Science - Short communications

Contribution ID: **21** Type: **not specified**

3-Dimensional reconstruction of the thermal X-ray emission in solar flares

Since October 2022, for the first time, two indirect X-ray imagers, the Spectrometer/Telescope for Imaging X-rays (STIX) on board Solar Orbiter and the Hard X-ray Imager (HXI) on board the Chinese ASO-S mission, are simultaneously observing the Sun in the hard X-ray regime. Given that the two telescopes have different vantage points on the star, it is possible to combine their stereoscopic observations for addressing the 3-dimensional reconstruction of the thermal X-ray emission in solar flares. In this presentation, we describe our 3-dimensional imaging technique based on simultaneous observations of solar flares provided by STIX and HXI. We show preliminary results in the case of a flaring event that occurred on 2024 October 1, and we demonstrate the potential of this methodology for studying the thermodynamic properties of the flaring thermal emission.
Piana M. F.,

Primary author: PALUMBO, Barbara (Università di Genova)

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Presenter: PALUMBO, Barbara (Università di Genova)

Session Classification: Metis Science - Short communications

Contribution ID: **22** Type: **not specified**

PROBA-3/ASPIICS Science Overview

PROBA-3 is the next ESA mission in the PROBA line of small technology demonstration satellites that was launched on 5 December 2024. It is currently in the commissioning phase. PROBA-3 is a mission dedicated to the in-flight demonstration of precise formation flying techniques and technologies. The PROBA-3 mission will place two small satellites in a highly elliptical orbit around the Earth. The two satellites will 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 will allow observing the inner corona close to the solar limb with very low straylight. PROBA-3 is also a Mission of Opportunity in the ESA Science Programme. The scientific objectives of ASPIICS will be described, and the advantages of distributing the coronagraph over two spacecraft will be discussed.

Primary author: ZHUKOV, Andrei (Royal Observatory of Belgium)

Presenter: ZHUKOV, Andrei (Royal Observatory of Belgium)

Session Classification: Metis & Friends

Contribution ID: **23** Type: **not specified**

Metis, ASPIICS and CODEX: Perspectives for Joint Science

In 2024, the coronagraphs ASPIICS and CODEX will be launched on the formation flying PROBA-3 ESA mission and on the ISS with a NASA-KASI-INAF mission, respectively. The 150-m separation between the formation-flying Coronagraph and Occulter satellites of PROBA-3 will allow long-duration, eclipse-like imaging of the inner corona, down to heliocentric heights of 1.1 solar radii. Besides the cold (1.e+4 K) He I D3 587.6 nm, and hot (2.e+6 K) Fe XIV 530.3 nm emission-lines, ASPIICS will image the visible-light, broadband polarized brightness (pB) of the K-corona. CODEX will measure the K-coronal intensity ratios at 390 nm and 410 nm where the strong absorption lines are concentrated in the photospheric spectrum, i.e., Ca II lines and the G band. The shape of the continuous coronal spectrum can offer a direct measure of the coronal electron temperature. The inner field-of-view of ASPIICS will complement that of Metis, already operational on Solar Orbiter since 2020. Additionally, tThe coronal electron temperature from CODEX will provide a critical physical parameter for the Metis Doppler-dimming diagnostics of the solar wind speed. The presentation will review the perspective opportunities for joint science with Metis, ASPIICS and CODEX.

Primary author: Dr FINESCHI, Silvano (Istituto Nazionale di Astrofisica (INAF))

Presenter: Dr FINESCHI, Silvano (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Metis & Friends

Contribution ID: **24** Type: **not specified**

News on MUSE

It will be reported on the progress of the MUSE NASA mission, with significant ASI-INAF contribution. MUSE will use EUV spectroscopy in 3 single-line bands (FeIX 171A, FeXV 284A, FeXIX 108A) to probe basic magnetic and heating processes in the solar corona. The lines are sensitive to plasma emission at about 1, 2.5 and >8 MK, respectively. Resolving the lines will allow to obtain information about non-thermal processes and plasma dynamics, and the 35 slits will allow to have this information at good time and space resolution (DePontieu et al. 2022, The Astrophysical Journal, 926:52). Italy is contributing through an ASI-INAF agreement which includes scientific modeling and diagnostics (University of Palermo, University of Calabria, INAF/OACN and OACt), and technological instrumentation, in particular, filters with CNT technology (University of Palermo, INAF/Astronomical Observatory of Palermo), mirrors (INAF/Astronomical Observatory of Brera) and coating tests (CNR/IFN Padua).

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Presenter: REALE, Fabio (University of Palermo)

Session Classification: Metis & Friends

Contribution ID: **25** Type: **not specified**

The ultimate EUV solar spectrometer: SOLAR-C/EUVST

SOLAR-C is the next JAXA-led devoted to the study of the Sun. The overarching science goals of the missions is to further our understanding of how underlying physical processes, acting on small scales, lead to the formation of the outer solar atmosphere and the solar wind, and how the solar atmosphere becomes unstable, releasing the energy that drives solar flares and eruptions.
The main mission payload is EUVST (EUV High-Throughput Spectroscopic Telescope), an EUV imaging spectrometer with slit-jaw imaging system designed to simultaneously probe the solar atmosphere from the chromosphere to the corona on a wide range of wavelengths and therefore of temperatures (from 0.1 to 10 MK), with a spatial resolution as low as 0.4" and a temporal cadence as high as 1 s.
Crucial to achieving these challenging observational parameters will be the high sensitivity of the instrument, surpassing all previous flown solar spectrographs. In this talk I will give an overview of the capabilities of the EUVST instrument, highlighting some science cases with an emphasis on synergies with other missions and facilities.

Presenter: ANDRETTA, Vincenzo (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Metis & Friends

Contribution ID: **26** Type: **not specified**

The European Solar Telescope: Current Status and Scientific Potential

The European Solar Telescope (EST) is a cutting-edge solar observatory that with its multi-wavelength focal plane instruments will study in detail the physical processes that occur in the magnetized plasma of the solar atmosphere and that are at the origin of space weather, and the causes of solar variability. a 4.2-meter primary mirror, the EST will be optimized to study the intricate interplay of magnetic fields within the solar atmosphere complementing the US DKIST telescope and the major space missions in heliophysics. By employing advanced imaging, spectroscopy, and spectropolarimetry techniques, the EST will provide unprecedented insights into the thermal, dynamic, and magnetic properties of the solar plasma across a wide range of scales. Italy is a key scientific and techological contributor to the EST project, playing a significant role in the development of various critical subsystems. The establishment of the European Solar Telescope Canarian Foundation (EST-CF) and the upcoming entry of Italy into EST-CF marks an important milestone, signifying the project's progression towards the goal necessary to sustain and keep alive the entire European and Italian heliophysics community.

Presenter: Prof. BERRILLI, Francesco (University of Rome Tor Vergata, Department of Physics)

Session Classification: Metis & Friends

Contribution ID: **27** Type: **not specified**

IBIS 2.0 Interferometric BIdimensional Spectrometer 2.0: overview and current status

The IBIS 2.0 project upgrades the Interferometric BIdimensional Spectrometer, which was operated at the Dunn Solar Telescope of the National Solar Observatory from 2003 to 2019, for installation at the THEMIS telescope of the Teide Observatory. The instrument combines two tunable Fabry-Ṕerot interferometers, narrowband interference filters, a polarimetric unit, fast cameras, and a suitable control for the acquisition of high-resolution spectropolarimetric data of the solar atmosphere in the 580-860 nm spectral range, with short exposures at high cadence under a remote control.
We provide an update on the design progress of the instrument, which underwent several phases, and status of the project that foresees AIV and on site installation by 2025.

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Session Classification: Metis & Friends

Contribution ID: **28** Type: **not specified**

Italian Radio facilities for Solar and Heliospheric Physics

Radio observations can probe and monitor the vertical structure and physical conditions of different layers of the solar atmosphere as a function of the observing frequency. Covering the entire radio range from millimeter to decameter wavelengths, it is possible to explore emission from the temperature minimum (at sub-millimeter waves) to the low corona (at meter waves) with the advantage that quiet Sun radio emission originates from thermal bremsstrahlung in local thermodynamic equilibrium. Focusing on very specific layers as for example the upper chromosphere and transition region through dedicated K-band observations (15-25 GHz), complex magnetic processes can be unveiled where the core of energetic processes occur (e.g. flaring active regions). We present a comprehensive picture and prospects of the growing network of radio facilities dedicated to solar radio observations focusing on the national plans about single-dish radio imaging and solar radio monitoring through dynamical spectroscopy. The link and integration of radio information with solar observations in other domains, including space-based facilities, can be very important (1) to constrain solar atmospheric models; (2) to characterise the flux density, spectral properties and long-term evolution of dynamical features (active regions, coronal holes, loop systems, streamers and the coronal plateau); (3) to predict powerful flares through the detection of peculiar spectral variations in the active regions, as a valuable forecasting probe for the Space Weather hazard network.

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Session Classification: Metis & Friends

Contribution ID: **29** Type: **not specified**

HPC for Solar Physics applications in Italy

High-performance computing (HPC) has long become a cornerstone for advancing solar physics. The application of HPC in this domain is particularly significant for the understanding of a number of fundamental physics questions when interlaced with realistic boundary and initial conditions or when different physical regimes need to be described simultaneously.
The solar wind, the solar corona, the interaction between different layers of the solar atmosphere, the propagation and dissipation of Alfvèn waves, the initiation and propagation of CMEs, the triggering and evolution of magnetic reconnection, the energetic cycle of coronal loops are just examples of the many questions that research groups in Italy are addressing extensively using HPC facilities.
Crucially, these investigations are becoming pivotal for the success of some of the most ambitious missions, as Solar Orbiter and the forthcoming MUSE and Solar-C.
In this talk we will report on some of these examples and we will address how CINECA is supporting the HPC efforts of solar physics.

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Session Classification: Metis & Friends

Contribution ID: **30** Type: **not specified**

Machine learning and inverse problems in heliophysics

This talk will illustrate some data- and model-driven computational approaches for data interpretation in heliophysics. Applications will involve flare forecasting using vector magnetograms, space weather prediction using both remote sensing and in-situ data, models for particle acceleration using hard X-ray observations, and desaturation of EUV maps

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Session Classification: Metis & Friends

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Synergies in high-resolution observations of the solar atmosphere to investigate small- to intermediate-scale energy release events

The interplay between emerging magnetic flux and pre-existing ambient fields is a key driver of small- to intermediate-scale energetic phenomena in the solar atmosphere, caused by magnetic reconnection. These events provide valuable opportunities to model eruptive phenomena on larger scales and necessitate a synergistic observational approach. We present observations of energy release events captured during coordinated campaigns involving high-resolution instruments from ground- and space-based facilities. Using spectropolarimetric data from the GREGOR and SST telescopes, we derive the magnetic configuration of the lower atmosphere, while the upper atmospheric response is analyzed using UV spectroscopic data and imaging from IRIS and Hinode. These observations are often complemented by continuous coverage from SDO. Our findings underscore the importance of coordinated observational efforts with current ground facilities and instruments on board satellites. In this context, it is beneficial to foster the scientific exploitation of high-resolution instruments on board Solar Orbiter, such as PHI and EUI. Looking ahead, we highlight the enhanced capabilities that future observatories and instruments, including the IBIS2.0 spectropolarimeter and instruments at the focal plane of the EST telescope, as well as the Solar-C and MUSE missions, will bring to study these phenomena, enabling deeper insights into the dynamics of the solar atmosphere.

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Session Classification: Metis & Friends - Possible joint science cases