SOLAR ORBITER

the eighth solar orbiter workshop

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Abstracts

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O1: Daniel Müller – Solar Orbiter: Science Overview

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Solar Orbiter completed its first close solar encounter at 0.32 au in March 2022 and has returned a trove of unique data, with early science results being presented at this workshop. By combining high-resolution imaging and spectroscopy of the Sun with detailed in-situ measurements of the surrounding heliosphere, Solar Orbiter enables us to determine the linkage between observed solar wind streams and their source regions on the Sun. Over the course of the 10-year mission, the highly elliptical orbit will get progressively more inclined to the ecliptic plane. Thanks to this new perspective, Solar Orbiter will deliver images and comprehensive data of the unexplored Sun's polar regions as well as the Sun's far side. This presentation will provide a science overview of the first 2 1/2 years in orbit, and a visual summary of the first close perihelion passage. Finally, we will give an outlook on future science opportunities, in particular in collaboration with other space- and ground-based observatories.

O2: Yeimy J. Rivera – Investigating He+ in the inner heliosphere with the ACE/SWICS and the Solar Orbiter/HIS

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The He+ population in the solar wind is often attributed to interstellar or inner source pick up ions (PUIs). PUIs are not native to the solar wind but instead formed from neutrals of an interstellar or interplanetary dust origin that become ionized. Their ionization can result from photoionization, charge exchange, or collisions with solar wind ions and electrons, respectively. Once ionized, the newly charged particles become responsive to the interplanetary magnetic field, joining the solar wind particles on their outward trajectory through the heliosphere. However, clues about their formation and origin lie in the particle's velocity distribution function (VDF). Along with typical non-thermal VDF features that indicate the particles have not yet coupled to solar wind conditions, PUI VDFs can also exhibit a highly peaked distribution around the solar wind speed that is thought to be formed through the interaction of interplanetary dust and the solar wind. Using a nonequilibrium ionization model of the solar wind we will explore charge exchange between solar wind alpha particles and neutral dust particles as the leading source of the peaked He+ population and provide estimates to the dust environment required to produce the He+ flux.

O3: Christopher J Owen – Investigations of the nature of the solar wind electron populations observed at energies > 50 eV by the Solar Orbiter Solar Wind Analyser Electron Analyser System (SO-SWA-EAS).

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See instrument papers in A&A, 2020.

Solar Orbiter carries a suite of sensors making up the Solar Wind Analyser (SWA) investigation, which has the responsibility of characterising the thermal and suprathermal electrons, the protons and alpha particles and the heavy ion composition of the solar wind. In this presentation, we concentrate primarily on observation from the Electron Analyser System (EAS) component of SWA, which is capable of sampling the near-spacecraft electron population with energies between ~0.1 eV and ~5 keV. Extracting the solar wind electron distribution from the lower part of this energy range (less than a few 10's eV) is difficult due to a complex electrostatic environment around Solar Orbiter set up by various spacecraft-plasma interaction processes. However, the higher energy part of the range, typical of the energy of the solar wind strahl population, is relatively unaffected by these issues. We thus focus on this higher energy range and examine the data collected during the first few months of the nominal mission phase (Jan – March 2022) during which the spacecraft moved from 1 AU at the Earth flyby to the first perihelion near 0.3 AU. We analyse this data in order to characterise the nature of the solar wind electron populations in the > 50 eV – 1 keV energy range and determine the nature of the strahl beam in the solar wind and its variations with distance and solar wind conditions. We also seek to characterise the occurrence conditions for a reported deficit in the electron distributions in this energy range in the opposite direction along the magnetic field to the strahl beam (e.g. Bercic et al., A&A, 2021). We describe the results of these investigations.

O4: Krzysztof Barczynski – The high-resolution observation of the slow solar wind sources

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The origin of the slow solar wind is still an open issue. It has been suggested that upflows at the edge of the active region and jets can contribute to the slow solar wind. How the plasma upflows are generated and which mechanisms are responsible for them are still outstanding questions.

We investigated the dynamics of jets and uplfow region using the unprecedented temporal (2 sec.) and spatial (2 pixel = 236 km) resolution data obtained on 30 March 2022 with the EUI high-resolution imagers (HRI) onboard Solar Orbiter. In addition, Solar Orbiter and the Solar Dynamics Observatory (SDO) were located in quadrature (~92°) which provide the opportunity for a stereoscopic view. We used the Hinode/EIS (FeXII, FeXIII) spectroscopic data to find upflow regions in the corona. We defined the upflow region as an area with a Doppler velocity stronger than -5 km/s. The IRIS slit-jaw provides a high-resolution view of the transition region and chromosphere. We used HMI data to investigate the photospheric magnetic field and build the PFSS model.

The PFSS model shows open magnetic field lines rooted in the upflow region which indicates that the upflow region can contribute to the solar wind. The imaging data from HRI/EUI, SDO/AIA, and IRIS slit-jaw show numerous small-scale brightening and absorption features evolving in the upflow region. We suggest that small-scale structures can significantly influence an upflow region evolution.

We used the base and running difference maps of HRI and AIA to search for jets. The high-resolution data of the jets presents highly-dynamical substructures of the jets.

In summary, the HRI data provide more detail view on the small-scale structures in the upflow region and jets. These small-structures can play an important role in slow solar wind generation.

O5: Konrad Steinvall – Estimating the solar wind speed using low-frequency electric and magnetic field measurements

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Measuring the low-frequency electric fields in space is a very difficult task. Accurate measurements require not only that the E-field probes are sufficiently separated to measure the weak fields (≈1 mV/m) expected in the solar wind, but also that the electrostatic potential profile of the spacecraft and its solar panels is symmetric with respect to the probes.
In a recent study we showed that the low-frequency E-field measured by Solar Orbiter's RPW is often of high quality, and that we can use deHoffmann-Teller analysis on E and B data to deduce the solar wind speed. Our method makes use of the fact that solar wind current sheets in practice always have a deHoffmann-Teller frame, i.e. a reference frame in which E=0. Thanks to the frozen-in nature of solar wind current sheets and the super-Alfvénic flow of the solar wind, the velocity of the deHoffmann-Teller frame is a good estimate of the solar wind speed. By relating the low-frequency fluctuations in E and B associated with current sheet observations, we deduce the velocity of the deHoffmann-Teller frame. Using this method, we are able to estimate the solar wind speed, even when particle data are not available.
In this talk, we explain how we can use Solar Orbiter's low-frequency electric and magnetic field measurements to estimate the solar wind speed. We discuss the applicability of our method, the complications, and the current status of RPW's low-frequency E-field measurements.

O6: Stephanie Yardley – Slow Solar Wind Connection Science during Solar Orbiter's First Perihelion

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The Slow Solar Wind Connection Solar Orbiter Operation Plan (Slow Wind SOOP) was developed to utilise the extensive suite of remote sensing and in situ instruments on board ESA's Solar Orbiter to answer significant outstanding questions regarding the origin and formation of the slow solar wind. The Slow Wind SOOP was designed to observe open–closed magnetic field boundaries in order to link plasma measured in situ to specific coronal sources. The SOOP ran just prior to Solar Orbiter's first perihelion and observations were taken during two remote sensing windows (RSW1 and RSW2) between the 3 – 6th March and 17 – 22nd March 2022 while Solar Orbiter was at roughly a distance of 0.55 – 0.51 AU and 0.38 – 0.34 AU from the Sun, respectively. Coordinated observation campaigns were conducted by Hinode and IRIS (IHOPs 433 and 434).

The magnetic connectivity tool developed by IRAP was used along with low latency in situ data and observations from STEREO-A and SDO to guide the target pointing of Solar Orbiter. EUI, PHI and SPICE targeted an active region complex during RSW1, the boundary of a coronal hole and the periphery of a decayed active region during RSW2. Post-observation analysis using the magnetic connectivity tool along with in situ measurements, such as 3D velocity taken by SWA/PAS, and the radial magnetic field from MAG show that slow solar wind, with velocities between ~300 and 500 km/s arrived at the spacecraft originating from these source regions. In this talk I will discuss the detailed analysis of the combined remote and in situ datasets. The Slow Wind SOOP campaign, despite encountering many challenges, was very successful and provides a blueprint for planning future observation campaigns that rely on the magnetic connectivity of Solar Orbiter.

O7: Lloyd D. Woodham – Multi-Spacecraft Study of the Radial Evolution of Solar Wind Turbulence in the Inner Heliosphere

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Both Solar Orbiter and Parker Solar Probe continue to provide new insights into the fundamental physical processes that govern the heating of the solar corona and formation of the solar wind. One possible route for energy dissipation and heating is through the presence of a broadband turbulent cascade of energy from large to small scales, mediated by non-linear interactions between counter-propagating Alfvénic fluctuations. The availability of high-resolution in situ measurements of electromagnetic fluctuations and particle velocity distributions from a constellation of spacecraft in the inner heliosphere allows us to study the radial evolution of the plasma as it flows outward from the Sun. We take advantage of a radial alignment between the Parker Solar Probe, Solar Orbiter and Wind spacecraft during February 2022 to investigate the evolution of the anisotropy of the turbulent fluctuations within the same plasma stream. For each spacecraft, we compute wavelet spectra of the magnetic field fluctuations, binned as a function of the Doppler-shifted proton gyroscale $k_R\varrho_p$ and the angle between the local mean magnetic field, $\mathbf{B}_0$, and solar wind flow, Θ_{VB}. We then compare the in situ observations to theoretical predictions of the power anisotropy for a model of linear Alfvéen waves. Finally, we discuss the possible mechanisms for turbulent dissipation consistent with our results and the implications for solar wind heating and acceleration.

O8: Tim Horbury – Switchbacks, microstreams and broadband turbulence in the solar wind

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Switchbacks are a striking phenomenon in near-sun coronal hole flows, but their origins, evolution and relation to the broadband fluctuations seen farther from the Sun are unclear. We aim to determine the scales of variability of switchbacks and, using measurements of the same solar wind stream at two distances, investigate statistically if switchback variability is related to the larger scale properties of fluctuations near 1 AU. We use the near-radial line-up of Solar Orbiter and Parker Solar Probe during the latter's sixth perihelion encounter in September 2020 when both spacecraft were in wind from the Sun's Southern polar coronal hole. Using the measured solar wind speed, we map measurements from both spacecraft to the source surface and consider the variations with source Carrington longitude of parameters such as velocity, density, composition and fluctuation levels. The patch modulation of switchback amplitudes at Parker at 20 solar radii was associated with speed variations similar to microstreams and corresponds to solar longitudinal scales of around 5-10 degrees. At Orbiter near 1 AU, this speed variation was absent, probably due to interactions between plasma at different speeds during their propagation. The alpha particle fraction, which has recently been shown to vary with patches at 20 solar radii, varied in the same way at 1 AU. The switchback modulation scale of 5-10 degrees, corresponding to a temporal scale of several hours at Orbiter, was present as a variation in the average deflection of the field from the Parker spiral. While limited to only one stream, these results suggest that in coronal hole flows, switchback patches are related to microstreams, perhaps associated with supergranular boundaries or plumes. Patches of switchbacks appear to evolve into large scale fluctuations, which might be one driver of the ubiquitous turbulent fluctuations in the solar wind.

O9: Victor Réville – On flux ropes born in helmet streamers

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The solar wind, in particular the slow component, harbors many dynamical structures. Density perturbations have been observed with coronagraphs and heliospheric imagers for more than 20 years. These so-called "blobs" seem to be released periodically from the low corona, in association with downflows that could be the signature of magnetic reconnection. In situ measurements have been able to associate (at least) part of these density structures to flux ropes, i.e. helical structures connected to the Sun. In this talk, I will review recent efforts to explain the origin of these structures and their relation to helmet streamers and the heliospheric current sheet (HCS). Using 2.5D and 3D simulations, I will show how helmet streamers are naturally unstable and lead, in a two-step process, to the release of flux ropes and density perturbations. The periodicity recovered in the simulations are consistent with observations and involve the ideal tearing mode at high Lundquist numbers. Comparing 3D MHD simulations with data of Parker Solar Probe and Solar Orbiter, I will show that a lot of the observed dynamics is consistent with numerous flux ropes born at the tip of helmet streamers and propagating close to the HCS. Finally, I will discuss the 3D structures of these flux ropes and the possible relation between the onset of the streamers instability and the thermal structure of the corona, controlled by the separatrice and quasi-separatrice network.

O10: Natalia Zambrana Prado – Measuring changes in the elemental composition of the solar corona with SPICE

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One of the most important goals of the Solar Orbiter mission is understanding the link between solar activity on the surface in the corona and the inner heliosphere. This has been a complicated task to pursue since the solar wind evolves as it streams further and further from the Sun. However, one way forward is by using composition data. Indeed, the First Ionization Potential (FIP) effect leads to an enhancement in the abundances of certain elements in the solar corona in given structures on the Sun and, unlike temperature or density, elemental composition remains unchanged.

Solar Orbiter brings us thus closer than ever to being able to determine the source region of the slow solar wind since its spectrometer SPICE can give us the composition of the solar corona and in-situ it can use SWA/HIS to determine these abundances in the wind. We show the results of the Linear Combination Ratio (LCR) method applied to recent observations performed with SPICE. The LCR method relies on optimizing linear combinations of spectral lines and requires no previous Differential Emission Measure (DEM) determination. This method can be telemetry efficient while remaining reliable.
All the methods and tools have been developed with the goal to make abundance measurements routinely available to the solar community. With the LCR method, we can use as little as four spectral lines to provide a new perspective on previous data, allow us to analyze and design SPICE observations and could even help design the next generation of EUV spectrometers through line selection.

O11: Donald M. Hassler – Composition Studies to Link the Sun & Heliosphere with SPICE on Solar Orbiter

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The Spectral Imaging of the Coronal Environment (SPICE) instrument is one of the key remote sensing instruments on the Solar Orbiter mission. SPICE is an imaging coronal spectrograph to observe chromospheric and coronal emission lines and remotely determine plasma properties and fill a critical gap in understanding the linkage between in-situ measurements of solar wind streams and their source regions at the Sun. We will discuss initial observations with SPICE and the strategy to use composition measurements to relate solar wind structures to their source regions on the Sun.

O12: Andrew P. Dimmock – Mirror mode storms observed by Solar Orbiter

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Mirror modes are ubiquitous in space plasma and have been investigated at many locations such as planetary magnetospheres, comets, and solar wind. They grow from pressure anisotropy and together with other instabilities, they play a fundamental role in constraining the free energy contained in the plasma. This study focuses on mirror modes observed in the solar wind by Solar Orbiter for heliospheric distances between 0.5 and 1 AU. Typically, mirror modes have timescales from several to tens of seconds and are considered quasi-MHD structures. In the solar wind, they also generally appear as isolated structures. However, in certain conditions, prolonged and bursty trains of higher frequency mirror modes are measured, which have been labeled previously as mirror mode storms. At present, only a handful of existing studies have focused on mirror mode storms, meaning that many open questions remain. In this study, Solar Orbiter has been used to investigate several key aspects of mirror mode storms: their dependence on heliospheric distance, association with local plasma properties, temporal/spatial scale, amplitude, and connections with larger-scale solar wind transients such as CMEs and SIRs. The main results are that mirror mode storms often approach local ion scales and thus break the commonly assumed long-wavelength assumption. They are typically observed close to current sheets and downstream of interplanetary shocks. The events were observed during slow solar wind speeds and there was a tendency for higher occurrence closer to the Sun. The occurrence is low, so they do not play a fundamental role in regulating ambient solar wind but may play a larger role inside transients.

O13: Tania Varesano – Analysis of SPICE Connection Mosaics from 2-3 March 2022 - Mapping Surface Composition to Link the Sun & Heliosphere

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We present results of our analysis of the SPICE Connection Mosaic SOOPs from 2-3 March 2022 to be used to map surface composition which can be compared to SWA/HIS In-situ observations to identify the footpoints of the solar wind observed at the Solar Orbiter spacecraft. The SPICE spectral lines were chosen to have varying sensitivity to the First Ionization Potential (FIP) effect, and therefore the abundances (and intensities) vary significantly depending on whether they are emitting from the corona or photosphere. We use two analysis techniques for determining the relative abundances in the corona; 1) optimizing linear combinations of spectral lines (Zambrana Prado & Buchlin, 2019), and 2) a technique which finds the best fit DEM and abundances simultaneously (Plowman et al, 2022). We will compare the pros and cons of each technique in the context of planning for future observations.

O14: Marilena Mierla – Eruptions observed by EUI/FSI onboard Solar Orbiter

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Since the launch of Solar Orbiter in February 2020, EUI's FSI telescope observed tens of spectacular prominence eruptions. The most spectacular one which was studied in detail was the eruption on February 15 2022, as it reached heights larger than 6 solar radii in the 30.4 nm channel of the FSI instrument.

We will present some of these eruptions and describe the science which was done so far. We will also outline the role that FSI can play in the future studies of the solar eruptions to large distances from the Sun.

O15: David Long – The Energetics of a Solar Jet in a Polar Coronal Hole

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Coronal jets are short-lived eruptive features commonly observed in polar coronal holes and are thought to play a key role in the transfer of mass and energy into the solar corona. We describe unique contemporaneous observations of a coronal blowout jet seen by the Extreme Ultraviolet Imager onboard the Solar Orbiter spacecraft and the Atmospheric Imaging Assembly onboard the Solar Dynamics Observatory. The coronal jet erupted from the south polar coronal hole, and was observed with high spatial and temporal resolution by both instruments. We find kinematics of ~100-200 km/s across the lifetime of its observed propagation, with a distinct kink in the jet where it impacted and was subsequently guided by a nearby polar plume. A Differential Emission Measure analysis using the SDO/AIA observations revealed no clear signal of the jet, indicating that the erupting material was most likely much cooler than the coronal passbands used to derive the DEM. This is consistent with the very bright appearance of the jet in the Lyman-alpha passband observed by SO/EUI. The DEM was used to estimate both the radiative thermal energy of the source region of the coronal jet (~7×10^{25} ergs) and the kinetic energy of the jet surge (~3×10^{25} ergs). These estimates suggest that the combination of radiative and kinetic energy released in this coronal jet is comparable to the energy of a nanoflare.

O16: A. Bemporad – A Coronal Mass Ejection followed by a prominence eruption and a plasma blob as observed by Solar Orbiter

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On February 12, 2021 two subsequent eruptions occurred above the West limb, as seen along the Sun-Earth line. The first event was a typical slow Coronal Mass Ejection (CME), followed ~7 hours later by a smaller and collimated prominence eruption, originating Southward with respect to the CME, followed by a plasma blob. These events were observed not only by SOHO and STEREO-A missions, but also by the suite of remote sensing instruments on-board Solar Orbiter (SolO). This work shows how data acquired by the Full Sun Imager (FSI), Metis coronagraph, and Heliospheric Imager (SoloHI) from the SolO perspective can be combined to study the eruptions and the different source regions. Moreover, we show how Metis data can be analyzed to provide new information about solar eruptions.

Different 3D reconstruction methods were applied to the data acquired by different spacecraft including remote sensing instruments on-board SolO. Images acquired by both Metis channels in the Visible Light (VL) and H i Ly-α line (UV) were combined to derive physical information on the expanding plasma. The polarization ratio technique was also applied for the first time to the Metis images acquired in the VL channel. The two eruptions were followed in 3D from their source region to their expansion in the intermediate corona. Thanks to the combination of VL and UV Metis data, the formation of a post-CME Current Sheet (CS) was followed for the first time in the intermediate corona. The plasma temperature gradient across a post-CME blob propagating along the CS was also measured for the first time. Application of the polarization ratio technique to Metis data shows that, thanks to the combination of four different polarization measurements, the errors are reduced by ~5–7%, thus better constraining the 3D distribution of plasma.

O17: Phillip Hess – First Solar Transients Observed by SoloHI

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The SoloHI instrument was built to provide observations of the heliosphere just beyond the coronagraph field of view, where many key processes governing CME evolution and interaction with the solar wind are believed to occur. Since the instrument door was opened to begin observing in June 2020, a number of transient structures have been observed. Many of these structures are smaller blobs propagating into the solar wind, but an increase in solar activity coinciding with the first science orbit of the mission has provided observations of a number of large CMEs, including geoeffective and SEP-generating events.

We present SoloHI observations of these eruptions, as well as the earliest attempts to address open questions governing CMEs in the heliosphere with this new and exciting data set. These efforts include combining SoloHI data with the other available observations from SolO, as well as other spacecraft throughout the heliosphere. We demonstrate the degree to which these complimentary observations agree with one another, while highlighting the additional details provided by the SoloHI vantage point.

O18: Hanna Strecker – Active region evolution observed on the far side solar photosphere with the full disc telescope of SO/PHI

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The Full Disc Telescope (FDT) is one of the two instruments of the Polarimetric and Helioseismic Imager (PHI) on board the Solar Orbiter (SO) spacecraft. The FDT enables observations of the full disc of the solar photosphere during all phases of Solar Orbiter's orbit and provides intensity, magnetic field, and LOS velocity images. This is of particular interest for studying the evolution of active regions. Until now, such studies have been limited by solar rotation, which restricts the observation times of active regions to their visibility on the solar disc from Earth. During different phases of the orbit, SO/PHI observes, partially or completely, the far side solar photosphere. Combining such data, of the solar far side, with observations from telescopes observing the solar earth-facing side provides the unique opportunity to study active regions over a full rotation period of the Sun, or even longer.

We use intensity maps and magnetograms gained from FDT observations of SO/PHI from Solar Orbiter's first opposition during cruise phase in February 2021. These far side data are combined with near-Earth data from the Helioseismic and Magnetic Imager (HMI) flying on board the Solar Dynamics Observatory.

We trace four small active regions from the near-Earth side in HMI magnetograms, to the far side of the Sun, where they are observed by the FDT of SO/PHI. Three of the active regions decay on the far side of the Sun. One of the active regions continues to develop while moving across the solar far side. Pores appear in intensity images before the region rotates back into the field of view of HMI. This combination of data provides the longest, almost uninterrupted study of active regions in magnetograms of the solar photosphere, so far. As such, it highlights one of Solar Orbiter's unique capabilities in combination with near-Earth observations.

O19: Yara De Leo – In-flight radiometric calibration and characterization of the Metis VL and UV channels and first applications

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Metis is the coronagraph aboard the ESA/NASA Solar Orbiter spacecraft and it has been designed to observe the extended solar corona with two channels: the ultraviolet hydrogen Lyman-α channel (121.6 nm) and the visible light channel (580-640 nm - in both polarized and total brightness).

Since the commissioning phase soon after the launch in February 2020, during the cruise phase and, into the nominal science phase, Metis has performed regular and extensive observational campaigns with the aim of characterizing the response of the two channels. Amongst the different calibration and characterization activities performed, observations of stars transiting the instrument's field of view (FoV) have proven to be crucial to verify the radiometric response of the instrument over the FoV and to monitor its evolution.

Targets have been carefully selected as bright non-variable stars with known R magnitude for the calibration of the VL channel and as bright O and B stars with known and stable emissions around 121.6 nm for that of the UV channel.

A comparison between the Metis calibrated images of the solar corona and the ones from other experiments (STEREO-A/COR2, LASCO-C2, UVCS) was also performed in order to check the coherence of the physical quantities obtained. In this work, we describe the results inferred from the stellar calibration campaigns and from the validation activities.
Eventually, we also show some first applications of the calibration result to observations of the quiescent and eruptive corona.

O20: Ronan Laker – Real time CME forecasting using Solar Orbiter:

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Space weather can create significant damage/disruption on Earth, much of which can be mitigated with a prior warning. This is normally provided by remote sensing data, which estimates the initial parameters and produces a prediction of the arrival time. However, this cannot give an accurate prediction for the internal magnetic structure, which is crucial for determining the geo-effectiveness of the CME. Mission concepts for an upstream solar wind monitor at 0.5AU have been proposed, but require currently inaccessible solar sail technology. Fortunately, Solar Orbiter had a rare opportunity to emulate this future concept in March 2022, when it crossed the Sun-Earth line at 0.5AU. Thanks to the work of the MAG team, we were able to see almost real time magnetic field measurements, allowing us to predict the arrival and magnetic structure of two CMEs up to a day in advance. The magnetic structure and arrival times were accurate between Solar Orbiter and L1 measurements, proving the efficacy of an upstream solar wind mission. In addition, we assessed the prediction capabilities for the ambient solar wind, which was also accurate, and could be used to predict the arrival of co-rotating interaction regions, which can also drive space weather at Earth. Finally, we look ahead to April 2023 when this opportunity will repeat, with the Sun closer to solar maximum.

O21: Russell A. Howard – Observation of Unusual CME Topologies

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The Parker Solar Probe (PSP) achieved its lowest perihelion of 13.2 Rs on 21 November 2021 in Orbit 10. This perihelion distance will be the same for the next six orbits. At the PSP perihelion of 13.2 Rs, the combined field of view of the two telescopes that make up the Widefield Instrument for Solar PRobe (WISPR) covers a radial distance between about 3.1 and 25 Rs. The WISPR observations obtained during the 10th solar encounter (16-25 November 2021) reveal some very unusual phenomena. Among them, the observations reveal what appears to be a small magnetic flux rope (MFR) embedded within a larger MFR Coronal Mass Ejection (CME). Another observed oddity was the interaction between a slow CME and a faster CME seemingly traveling in its wake. When the faster CME reached the slower one, it caused the FR of the preceding (slower) CME to be pancaked and (significant) deformation of the faster CME following behind. These distortions lasted through the passage and appeared to be there after the faster one had passed by the slower one. Here we describe these observations and discuss the new findings allowed by the novel observations obtained from distances never before achieved.

O22: Fatima Kahil – The magnetic drivers of EUI campfires seen by SO/PHI

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Campfires are the smallest ever detected localised brightenings in the quiet-Sun, observed by the High Resolution Imager (EUI/HRI) of the Extreme Ultraviolet Imager (EUI) at 17.4 nm on-board the Solar Orbiter (SO) spacecraft. The photospheric magnetic field configuration and its evolution, underlying campfires, are key to understanding the drivers of these heating events. The Polarimetric and Helioseismic Imager (SO/PHI) on-board SO offers a unique opportunity to provide co-observations at a spatial resolution similar to EUI (1 arcsecond). To this end, we employed magnetograms recorded by the High Resolution Telescope of PHI (PHI/HRT, 617.3 nm) to study the magnetic field below the EUI campfires observed during the cruise-phase of SO in February 2021. During this period, both instruments achieved a spatial resolution of 380 km on the Sun. We observed signatures of magnetic flux cancellation in the vicinity of most of the heating events, indicating that magnetic reconnection in the lower atmosphere could be their main driver. However, the PHI/HRT timeseries were not ideal in terms of cadence and overlap with the EUI/HRI observations to confirm this scenario. This unique study is revisited, now with the data acquired by both instruments during the first and second Remote Sensing Windows (RSWs) of SO's nominal phase in two observational campaigns on March 8th and 17th, 2022. At orbital distances of 0.489 AU and 0.379 AU from the Sun, both instruments achieved a spatial resolution of 360 km and 280 km, respectively. These novel data offer new insights into the photospheric counterpart of EUI campfires and consequently, improve our understanding of the underlying magnetic processes driving these events.

O23: David Berghmans – First Perihelion of EUI

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The Extreme Ultraviolet Imager (EUI), onboard Solar Orbiter, consists of 3 telescopes, the Full Sun Imager (FSI) and the High Resolution Imagers in EUV (HRIEUV) and in Lyman-alpha (HRILYA). Solar Orbiter/EUI started its Nominal Mission on 2021 November 27. EUI is imaging from the largest scales in the extended corona off limb, down to the smallest features at the base of the corona and chromosphere. EUI is therefore a cornerstone instrument for the connection science that is at the heart of the Solar Orbiter science goals. The highest spatial resolution of EUI is achieved when Solar Orbiter passes through the perihelion of its orbit. On 2022 March 26, Solar Orbiter reached for the first time a distance to the Sun of only 0.323 au. No other coronal EUV imager but EUI came ever this close to the Sun. In this paper, we review the obtained EUI data sets during the period 2022 March-April, when Solar Orbiter quickly moved from alignment with the Earth (2022 March 6), to perihelion (2022 March 26), to quadrature with the Earth (2022 March 29). We will highlight the first observational results in these unique data-sets and we report on the in-flight instrument performance. EUI has achieved the highest resolution images ever of the solar corona in the quiet Sun and polar coronal holes. Several active regions were imaged at unprecedented cadences and sequence durations. We identified in this paper a broad range of features that require deeper studies. For each telescope we report also pending performance issues. We conclude with an invitation to participate in the EUI research by make use of the EUI open data policy and the EUI Guest Investigator Program.

O24: Z. Huang – EUI and SPICE observations of campfires

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Thanks to its unprecedented spatial resolution and cadence, the High Resolution EUV telescope (HRIEUV), part of the Extreme Ultraviolet Imager (EUI) aboard Solar Orbiter, recently uncovered small-scale and short-lived solar EUV brightenings termed campfires. Here we study three campfires that we identified in HRIEUV data and that are within the small areas covered by the slit of Spectral Imaging of the Coronal Environment (SPICE) EUV spectrometer also aboard Solar Orbiter. The detection of these campfires by SPICE allows us to obtain detailed information on their thermal evolution. These campfires all having a linear size of less than 4 Mm. One of them exists for only about 40 seconds while the other two have a lifetime of several minutes.

We find that (i) the detection of these campfires is at the limit of the SPICE capabilities as they couldn't have been independently identified in the data without the aid of HRI observations; (ii) the two of these campfires with longer lifetimes are observed in Ne VIII (0.6 MK); (iii) all of them are detectable in OVI (0.3 MK) and the two longer-lived ones also in other transition region (TR) lines; and (iv) in one case, we observe two peaks in the intensity light curve of TR lines while that of Ne VIII reaches its peak in the middle. These results indicate that at least some campfires may barely reach coronal temperatures. More extended studies will be necessary to further establish what fraction of these events has these properties so to allow putting some constraint on their role in the heating of the solar corona.

O25: Säm Krucker – Hot (>10 MK) CME Cores seen in X-rays by Solar Orbiter/STIX

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While the brightest X-ray emissions from solar eruptions originate from flare arcades in the lower corona, the escaping core of the associated Coronal Mass Ejection (CME) can be as well seen in X-rays, at least for the largest events. With present day X-ray observatories, however, the escaping hot core can only be observed in highly occulted events where the solar limb fully covers the main flare loops allowing us to detect the much fainter emission from the CME core. In collaboration with the Heliophysics fleet, Solar Orbiter can study such events from multiple vantage points. The GOES X1 class flare from 2022-Apr-17 is an excellent example of such an event where the flare was fully seen from Earth (FERMI, AIA, XRT), while Solar Orbiter only was able to detect emission from 0.18 solar radius above the flare site. The escaping hot core is clearly detected by STIX revealing core temperatures up to 23 MK. The estimated GOES class of the hot core alone is GOES A4, about 3000 times fainter than the flare itself. An example with an even brighter X-ray source from the CME is the flare SOL2022-02-15 with excellent EUI/FSI coverage. For this event, the escaping CME core not only shows a high temperature, but spectral X-ray observations indicates the existence of non-thermal (>10 keV) electrons within the CME core.

O26: Andrea Francesco Battaglia – STIX Hard X-ray Observations of Microflares Associated with Coronal Jets

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How particles are accelerated in the lower solar corona and how they subsequently gain access to interplanetary space are outstanding questions in heliophysics. Interplanetary Solar Energetic Particles (SEPs), that can be detected in-situ by Solar Orbiter and Parker Solar Probe, are generally accelerated by the shock waves of Coronal Mass Ejections (CMEs) or by flares at the Sun. The general picture describing solar flares is given by the standard flare scenario, in which magnetic reconnection that occurs in the corona reduces magnetic energy in favor of kinetic energy of high-energy particles. On the one hand, the accelerated particles heat the ambient solar plasma to temperatures of the order of tens of MK and generate hard X-rays via bremsstrahlung emission, whereas, on the other hand, particles can escape along open magnetic field lines into the interplanetary space. Solar flares that generate interplanetary SEPs have often been observed to be associated with coronal jets, since these events, in the standard picture, indicate acceleration via magnetic reconnection with field lines that are open to interplanetary space.

In the past decades, extensive research on coronal jets has been carried out from both an observational and numerical perspective. Nevertheless, the process at the origin of the particle acceleration and the subsequent escape toward interplanetary space still needs to be understood. In this talk, we will first of all review the diagnostic capabilities of STIX for studying a large range of flare GOES classes. Secondly, we will discuss STIX microflare observations associated with coronal jets that show evidence of escaping particles in the interplanetary space.

O27: Conrad Schwanitz – High spatial imaging of coronal upflows in the quiet Sun – sources of solar wind?

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In previous work, we have determined sources of upflows in the quiet Sun and coronal holes that do not have a strong intensity enhancement such as a jet [see Schwanitz et al., 2021]. These upflows could be particularly important as an additional (and nearly 'invisible') source of the solar wind.

During the first science perihelion of Solar Orbiter, joint observations were made with the Hinode spacecraft allowing for coronal Doppler velocity measurements. We combined spectroscopic data from Hinode/EIS with imaging data from Solar Orbiter's EUV Imager (EUI) high resolutions imagers (with down to 135 km spatial resolution and 5 sec time cadence) and SDO's AIA to identify potential sources for the upflow regions.

Some of the upflow regions fall on bright points and active loops, which show changes in the magnetic field configuration and small changes in intensity. In contrast to that, a few upflows can be seen on quiet regions, which do not show strong intensity fluctuations or noticeable magnetic field changes. Many upflows region analysed are located next to regions with a gradient in intensity (sometimes increasing and sometimes decreasing). In addition, we combined the data with chromospheric data from the IRIS slitjaw images. We discuss the sources of the upflow, and determine if they fit within categories as small-scale brightenings or eruptions highlighted in our previous paper.

O28: George C. Ho – Interplanetary Ion Flux Dropouts Across Multiple ^{3}He-rich Events Observed on Solar Orbiter

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Solar Orbiter, a joint ESA/NASA mission, is studying the Sun and inner heliosphere in greater detail than ever before. Launched in February 2020, Solar Orbiter has already completed its first three orbits, reaching perihelia of 0.5 au from the Sun in June 2020, February and August 2021. During the first two years in orbit, Solar Orbiter observed multiple ^{3}He-rich Solar Energetic Particle (SEP) events inside 1 au. Even though these events were small, their spectral forms, ^{3}He content, and association with energetic electrons and type III bursts convincingly identifies them as ^{3}He-rich SEP events with properties similar to those previously observed at 1 au, and promising new insights as Solar Orbiter moves much closer to the Sun in 2022. In May 2021, we observed six ^{3}He-rich SEP events in close succession within 48 hours when Solar Orbiter was at 0.95 au. These events were likely released from the same active region at the Sun, and the particles arrived at Solar Orbiter in two batches with various abundances and intensities, showing strong anisotropies throughout. Multiple ion flux dropouts were also observed with these six ^{3}He-rich SEP events. The fact that we observed so many ion injections in such a short period of time indicates the ^{3}He enrichment and acceleration mechanism can produce SEP from the same region very efficiently and with varying enrichment levels and intensities. In addition, we report for the first-time dropout features that spanned multiple ion events simultaneously. This implies the field line random walk that we observe at 1 au still maintains magnetic connections to a small region back at the Sun up to the entire duration of these events (~48 hours).

O29: Jonathan Nölke – Dark voids in the quiet Sun corona and their magnetic nature:

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In high-resolution observations of the quiet Sun corona we find regions with greatly reduced extreme-UV emission. These voids cover an area of up to several supergranular cells. The aim of our study is to understand why the voids appear darker in coronal emission by investigating the underlying magnetic field structures. Essentially, there are at least two possible scenarios that could explain these voids. (1) These voids could be (locally) open magnetic structures that are dark for the same reason why also coronal holes appear dark, or (2) that they are a result of lower levels of magnetic heating due to the intrinsically less (unsigned) surface magnetic flux over which they originate than the typical quiet Sun corona.

To distinguish between these two scenarios, we use coronal imaging data from the Extreme Ultraviolet Imager (EUI) in its high-resolution channel at 174 Å showing mostly plasma at about 1 MK and photospheric magnetic field data from the Polarimetric and Helioseismic Imager (PHI), both onboard Solar Orbiter. We use combined observations of EUI and PHI of several solar targets, including a quiet Sun patch and an active region with surrounding quiet Sun.

Our results point to a mixture of the two scenarios for these voids. On the one hand we see a reduced unsigned magnetic flux in the coronal voids, on average it is reduced by about 20% in comparison to the quiet sun. On the other hand, most coronal voids also exhibit some flux imbalance, even though at the lower end of what is found in coronal holes. Our preliminary conclusion is that the voids are caused by both, reduced heating and energy escaping along the open magnetic field.

O30: Luciano Rodriguez – The eruption of 22 April 2021 as observed by Solar Orbiter, STEREO and Earth bound instruments

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The Extreme Ultraviolet Imager (EUI) onboard Solar Orbiter (SolO) observed an eruption with its Full Sun Imager (FSI) in both of its channels (17.4/30.4 nm), on 22 April 2021. At the time, the spacecraft was at 0.87 au from the Sun. The eruption was seen at the southwest limb, starting at 04:24 UT, with the source located at S20W103 from SolO perspective, slightly back-sided. From the Earth's perspective it was seen at S20W05 (close to disk centre), SDO/AIA and PROBA2/SWAP observed dimmings and an associated large-scale coronal wave starting around 04:07 UT. STEREO-A/EUVI saw similar signatures of an eruption starting around 04:17 UT, on-disk at S20W50. The corresponding CME was observed shortly after by several coronagraphs. SOHO/LASCO-C2 observed a partial halo CME starting around 06:00 UT. STEREO-A/COR2 recorded a clear structured CME seen from around 05:23 UT. SolO/Metis observed the CME from the SolO perspective at 06:05 UT. SolO/STIX observed the associated X-ray flare, which was partially occulted. This allowed the characterization of both the thermal plasma and any potential contribution of non-thermal electrons in the tenuous coronal source. The X-ray source location is compared to the coronal structures seen by EUI in order to establish that STIX only sees the top part of the flaring loops, while most of the flare – in particular the non-thermal foot points – remains occulted. The corresponding ICME arrived at Earth on 24 April 2021, it was driving a shock and created minor geomagnetic storm conditions. We simulated the CME with the 3D MHD heliospheric model EUHFORIA. We provide an analysis of the eruption as observed by these various instruments from different vantage points. The combination of data from Solar Orbiter as well as other space-based assets with numerical modeling clearly showcases the scientific potential for the science phase of Solar Orbiter.

O31: Daniele Calchetti – MHD waves in the photosphere with SO/PHI-HRT

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The Polarimetric and Helioseismic Imager (PHI) on Solar Orbiter has successfully acquired spectropolarimetric data of the solar photosphere during the first science orbit of the nominal mission phase. In June 2022, data from the Remote Sensing Window 1 have been released to the SO/PHI extended team and will be made public in September 2022. The combination of the excellent polarimetric sensitivity of the instrument and absence of interference of the Earth’s atmosphere provide an ideal scenario to study the presence of MHD waves in the solar photosphere. Two time series have been taken into consideration: an active region observed on March 7th and a quiet-Sun dataset acquired on March 8th. The existence of resonant modes in the active region has been investigated by looking at the power spectra within a specific magnetic field range (B-omega analysis) and studying the phase difference between different diagnostics. We performed an analysis of wave modes in network regions taking advantage of the full Stokes vector observed by the instrument. Data acquired by SDO/HMI have been also considered as a case study for co-temporal observations at different spatial resolutions. A brief overview of the data that have been released and the results of these analyses will be presented during the talk.

O32: Marco Stangalini – Spectropolarimetric analysis of MHD wave modes in high resolution PHI data

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Magneto-hydrodynamic (MHD) waves are thought to be important mechanisms for the energy transfer in the solar atmosphere. Here, by taking advantage of high resolution and seeing-free PHI observations of the solar photosphere, we investigate the signature of MHD waves in different spectropolarimetric quantities. Preliminary results show the existence of multiple wave modes in different magnetic waveguides, which can be also used for diagnostic applications in the solar atmosphere.

O33: Kinga Albert – A first multi-angle look at intensity contrast of solar network and faculae

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Variations of solar irradiance are mainly driven by photospheric magnetic fields confined in kilogauss magnetic concentrations. These concentrations manifest themselves as dark sunspots and bright network and faculae. As the magnetic field evolves and the Sun rotates, these features change in spatial distribution and amount as seen from a given vantage point, which in turn causes fluctuations in the solar irradiance.

The variation in the intensity contrast of faculae and network with magnetic flux density and distance from disc centre is directly relevant to understanding their contribution to solar irradiance variability. However, the study of this relationship based on single point of view observations becomes challenging for features close to the limb: the determination of their magnetic fields becomes more difficult, as a consequence of the changes in viewing geometry. Data from the Polarimetric and Helioseismic Imager on-board the Solar Orbiter spacecraft (SO/PHI) presents a new opportunity to overcome this observational constraint.

In this preliminary study, we augment SO/PHI full disc observations from September 2021, with data recorded by the Solar Dynamics Observatory/Helioseismic and Magnetic Imager (SDO/HMI) at the same time. In this period, the two instruments had 60°±10% separation in their heliographic longitude, which allows network and faculae close to the limb in one instrument, to occur closer to the disc centre in the other. This work therefore addresses the aforementioned limitations with earlier studies, which are confined to observations made from Earth's perspective alone.

O34: J. Schou – The ratio of horizontal to vertical displacement in solar oscillations estimated from combined SO/PHI and SDO/HMI observations

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One of the basic quantities that has never been directly measured in helioseismology is the (complex) ratio of the horizontal to vertical displacement of the p- and f-modes at the height at which the modes are observed. Indirect measurements have been made in the past, but unfortunately it is difficult to disentangle various physical and instrumental effects using observations from a single vantage point.

Using simultaneous observations of the same area of the Sun from two vantage points allows for a more direct estimate of this quantity.

Here we will show results based on combining SO/PHI and SDO/HMI observations. There appear to be some deviations from the values expected from a simple theory, indicating that a more accurate theoretical treatment is needed.

O35: Laura Rodríguez-García – Solar energetic electron events measured by the MESSENGER mission: Peak intensity and peak energy spectrum radial dependence statistical analysis

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We present a list of 62 solar energetic electron (SEE) events measured by the MESSENGER mission from 2010 to 2015, when MESSENGER heliocentric radial distance varied between 0.47 and 0.31 au. We performed a statistical study of the correlations between the SEE properties measured by MESSENGER and the parameters of the respective parent solar activity. For the events of the list that were also measured by magnetically aligned spacecraft near 1 au, we derived the radial dependencies of the SEE parameters. This study can be enhanced with data from currently operating missions simultaneously exploring closer regions of the Sun, such as Solar Orbiter, Parker Solar Probe and Bepi Colombo together with near 1 au spacecraft. As a preamble, we also present the radial dependencies for a shorter list of 12 SEE events measured by near 1 au spacecraft and by Solar Orbiter, around its first close perihelion at 0.32 au during February and March 2022. We find that the radial dependence of the peak intensity can be figured out as ∝ R**-α, where the mean value of the α index is close to α=+3 for a subsample of 28 events where the near 0.3 au and 1 au spacecraft were closely nominally magnetically aligned. The mean spectral index δ of a subset of 42 events where the spectrum could be analyzed is δ=1.94 ± 0.34, much harder than previous SEE studies near 1 au. There is a very strong correlation between the electron peak intensity and the X-ray intensity of the flare or the 3D CME-driven shock speed at the apex for well-connected events. The 3D CME width plays an important role independently of the 3D CME speed, with a high correlation for well-connected events between the electron peak intensity and the 3D CME width.

O36: Alexander Kollhoff – Solar energetic particle events observed by the Energetic Particle Detector (EPD) during cruise phase between 0.3 and 1 AU

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The Energetic Particle Detector (EPD) onboard Solar Orbiter is observing electrons and ions with energies from tens of keV up to hundred MeV. During the first four orbits of Solar Orbiter, the four different EPD sensors - The SupraThermal Electron Proton (STEP) sensor, the Electron Proton Telescope (EPT), the High-Energy Telescope (HET) and the Suprathermal Ion Spectrograph (SIS) - have observed numerous solar energetic particle (SEP) events with astonishing variations in their characteristics. With the increasing solar activity of the 25th solar cycle and the mission continuing on its unique orbit, SEP observations are now becoming more frequent and EPD is gathering remarkable in-situ measurements of these events at radial solar distances ranging from 0.3 to 1 AU.

We will give an overview of the various EPD observations including some of the smallest SEP events which were nicely resolved by EPD's excellent temporal and directional resolution. In comparison, we will also show some massive events with particles reaching energies up to hundred MeV which fill almost the entire inner heliosphere. Further we will highlight the capabilities and limitations of the different sensors and illustrate the scientific potential of the new observations made by EPD.

O37: Francesco Malara – Energetic particle propagation across a switchback

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Switchbacks (SB) are structures embedded in the solar wind that have been commonly detected near the Sun by Parker Solar Probe. SB-like structures have been observed also by Solar Orbiter at larger distances (Fedorov et al., A&A, 656, A40, 2021). SBs are characterized by a local inversion of the magnetic polarity, by a pronounced velocity-magnetic field Alfvénic-like correlation, and by nearly constant magnetic field intensity and plasma density. Based on these properties, a SB can be modelled as a pair of rotational discontinuities (RD), where the magnetic field makes a large-amplitude abrupt rotation followed by another opposite rotation. The effects of a RD in the propagation and transport of energetic particles has been examined in a recent paper (Malara et al., PRE, 104, 025208, 2021). Here we extend this study investigating the effects of a SB on the dynamics of high-energy particles, like protons of solar origin. Employing a numerical model where a SB is modelled by a pair of opposite RDs, we follow the dynamics of test particles propagating across a SB. The particle-SB interaction is influenced by the parameters defining the magnetic structure and by the initial pitch angle and gyrophase of particles. The particle motion is extremely complex and highly sensitive to the initial conditions, revealing a chaotic behaviour. Particle can temporarily be trapped either inside a single RD or bouncing back and forth between the two RD's. The resulting distribution of crossing time is calculated for different values of the model parameters. The pitch angle variation is evaluated for different initial conditions and the modification of particle distribution in the velocity space across the SB is investigated. Implications for energetic particle propagation in the solar wind magnetic irregularities are discussed.

O38: Karl-Ludwig Klein – The relativistic solar particle event on 28 October 2021: Evidence of particle acceleration within and escape from the solar corona

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We analyse particle, radio, and X-ray observations during the first relativistic proton event of solar cycle 25 detected on Earth (2021 Oct 28). The aim is to gain insight into the relationship between relativistic solar particles detected at or near Earth and the processes of acceleration and propagation in solar eruptive events.

We infer the initial solar release time of relativistic protons and electrons from measurements at ground-based neutron monitors and at SoHO, respectively. We compare the release times with the time histories of non-thermal electrons in the solar atmosphere and their escape to interplanetary space, as traced by radio spectra observed at ground-based observatories and different spacecraft, and by X-ray light curves and images from Solar Orbiter/STIX. The observations show evidence of electrons accelerated at a coronal shock wave and others that are confined in expanding magnetic structures related to a coronal mass ejection (CME). The radio spectra show tentative evidence that the confined electrons escape to the high corona and interplanetary space when the expanding flux rope of the CME reconnects with open magnetic fields in its neighborhood. The early release of relativistic protons and electrons to the interplanetary space occurs with one of these reconnection episodes.

The parent activity of this particle event is near the central meridian of the Sun. It is hence not connected to the Earth by a standard Parker spiral geometry, but the radio spectra at kilometre-wavelengths observed at Wind, STEREO A, Parker Solar Probe and Solar Orbiter show a connection of the parent active region with a wide range of longitudes in the interplanetary space. We discuss the observational evidence on the origin of the relativistic particles in space with respect to acceleration processes in the parent active region and at the CME-driven shock wave.

O39: Laura Hayes – Solar flare time-variability observed with Solar Orbiter/STIX.

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The X-ray emission associated with solar flare energy release typically exhibits pulsations and time-varying behavior. This emission variability, which can occur on timescales of seconds to tens of seconds, is thought to be linked to the energy release process itself, however to date the underpinning mechanisms causing the emission modulation remains unclear. The new X-ray imaging spectroscopic observations from the STIX instrument on-board Solar Orbiter provides a new opportunity to study this time-variability associated with solar flare emission, and to constrain the proposed mechanisms driving the modulation. STIX provides quantitative measurements with a time resolution as low as 0.3s of the intensity, spectra, and imaging of both thermal and non-thermal solar X-rays in the energy range of 4-150keV. This capability makes it uniquely suited to perform spatio-temporal analysis of flare X-ray emission over the timescales and energy ranges flare time-variability is typically identified. In this talk, I will highlight recent results of flare-time variability observations with Solar Orbiter/STIX, and how these can be used in coordination with other Solar Orbiter instruments observations to learn more about solar flare energy release.

O40: Natasha Jeffrey – Determining Solar Flare Hard X-ray Directivity using Stereoscopic Observations with Solar Orbiter/STIX and Fermi

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Solar flare particle acceleration is an extremely efficient process and understanding the acceleration mechanism remains a major challenge in solar physics. Hard X-ray (HXR) observations provide a direct link to flare-accelerated electrons and HXR directivity is a measure of the electron angular distribution, a prime diagnostic of the unknown electron acceleration mechanism, and various transport properties in the solar corona. However, to-date, HXR directivity has been difficult to measure, with different methods providing conflicting and often unreliable results. However, with the launch of Solar Orbiter/STIX and an upcoming fleet of X-ray instrumentation at Earth (e.g., ASO-S/HXI, Aditya/HEL1OS, PADRE), reliable stereoscopic observations measuring HXR directivity are now possible. Here, I will discuss the importance of measuring HXR/electron directivity during flares, show the first results of joint stereoscopic measurements with Solar Orbiter/STIX and Fermi, and explain how the electron directivity can be extracted from observations via comparison with current electron and X-ray modelling.

O41: Nicole Vilmer – Connecting energetic electrons at the Sun and in the Heliosphere through X-ray and radio diagnostics

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One of the main objective of the Solar Orbiter mission is concerned with the production of energetic particles in the heliosphere, in particular with understanding how particles are released from their acceleration sources and distributed in space and time in the heliosphere. For energetic electrons, part of this question can be addressed by combining X-ray and radio observations. Indeed, while downward moving electrons produce X-rays in the chromosphere, upward moving electrons may generate coherent radio emissions when propagating through the corona, such as radio type III bursts.

In this contribution, we shall present some preliminary results of the comparison of a few X-ray flares observed by STIX in the 4-150 keV range on Solar Orbiter with radio type III bursts detected by RPW (<10 MHz) on Solar Orbiter. The X-ray observations can be used to identify the flaring active regions and to derive the properties and emission sites of energetic electrons in the flaring active region. On the other hand, radio observations provide information on the escaping electrons and frequency drifts of radio bursts can be used to derive the bulk speed of these electrons.

As already known from previous observations, the link between HXR flares and radio type III bursts in the heliosphere (below 10 MHz) is not systematic. Indeed, while some hard-X-ray flares observed by STIX (even large ones) are not associated with radio bursts, some strong type III bursts are associated with tiny X-ray bursts. We will examine in this study on a few events, whether these non-systematic associations are due to different connectivities from the flaring active region to the interplanetary space or to the characteristics of the non-thermal electrons derived from HXR observations (energy spectrum, number of non-thermal electrons). We will also further examine a potential link between the drift rate and the characteristics of the HXR emissions (when associated) (non-thermal electron spectrum and number, positions of the HXR burst at the solar surface).

O42: Shane A. Maloney – Type-III radioburst velocities and associated SolarOrbtier/STIX X-ray spectra

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Solar flares are known to accelerate copious numbers of electrons. In the standard flare model electrons confined to closed magnetic fields produce the typical X-ray and thermal signatures in the solar atmosphere while those on open magnetic field lines can produce Type-III solar radio bursts (SRBs) in the high corona and interplanetary space. This work investigates the occurrence and relationship between Type-III radio bursts and the associated hard X-ray emission. It is believed that there is a relationship between the hard X-ray spectrum and SRB velocity (exciter), and some theoretical work has predicted the form of this relationship but this has yet to be confirmed observationally. A number of solar flares and associated Type-III SRB observed by SolarOrbiter/STIX and various space and ground based radio spectrometers were analysed. For each SRB and associated HXR emission the velocity of the SRB and slope HXR count spectrum were determined. The SRB velocities were found to be in the range $0.17c$ to $0.6c$ are in agreement with typical values found in the literature. An inversely proportional relationship between the average burst velocity and the count spectral index was found which supports the belief that the electrons responsible for Type-III SRBs and HXR emission are in fact related and likely have a common progenitor. In one specific case, an M1 flare, potential quasi-periodic particle pulsations (QPPs) in the radio and soft X-ray data are observed the the time evolution of the relationship is discussed.

O43: Sophie Musset – Multi-spacecraft observations of type III radio bursts

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The launch of Solar Orbiter and Parker Solar Probe provide for the first time the opportunity to study type III radio burst emissions measured at 4 different spacecraft in the heliosphere, with measurements at 1 a.u. by Wind and STEREO-A. These measurements allow us to observe the properties of single radio bursts from different point of view, and calculate the directivity of the radio emission. These observations can be used to study both the radio source properties and the radio-wave propagation in the heliosphere.

We present here the first measurements of type III radio burst emission by 4 widely-spaced spacecraft and compare these measurements to the predictions of radio propagation simulations with an anisotropic scattering of the radio-wave on the turbulent density fluctuations of the ambient plasma. We will then discuss how this combination of multi-spacecraft measurements and simulation can be used as a remote-sensing tool to estimate the level of anisotropy of the density fluctuations of ambient plasma in the inner heliosphere.

O44: Milan Maksimovic – The Radio and Plasma Waves (RPW) Instrument on Solar Orbiter: Performances and first results after two years in orbit.

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We will review the performances and results obtained by the Radio and Plasma Waves (RPW) Instrument during the first two year in orbit. RPW is designed to measure in-situ magnetic and electric fields and waves from 'DC' to a few hundreds of kHz. RPW is also capable of measuring solar radio emissions up to 16 MHz and link them to solar flares observed by the onboard remote sensing instruments. The obtained results concern a wide range of phenomena including: Whistler Waves, high resolution density measurements, dust impacts, Langmuir waves and solar radio emissions.

O45: Nicolina Chrysaphi – The angular dependence of spectroscopic solar radio measurements using multi-spacecraft observations

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Injections of non-thermal electrons into the heliosphere often manifest as intense radio emissions, the most common of which are known as Type III solar radio bursts. The emission frequency of solar radio bursts is closely related to the local plasma frequency of the heliosphere, meaning that they can be used to probe the local conditions of the solar corona and interplanetary space. However, observations of these radio emissions do not represent the true nature of the radio sources due to the scattering of radio photons. Such radio-wave scattering is induced by anisotropic density fluctuations in the heliosphere and impacts both the imaging and spectroscopic properties of radio sources in a frequency-dependent manner, where lower frequencies are affected to a larger extent. Using multi-spacecraft observations of several Type III bursts, including from Solar Orbiter and Parker Solar Probe, we investigate the angular dependence of spectroscopic radio observations due to the presence of anisotropic scattering. We present an improved estimation of the spectroscopic properties and probe whether the spacecraft position affects the recorded decay times. Comparing observations and state-of-the-art anisotropic scattering simulations introduces new constraints on the models used to describe heliospheric radio-wave scattering.

O46: Matthieu Kretzschmar – First detection of the magnetic component of type III radio burst

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On October 28, 2021, a powerful flare occurred on the Sun, which accelerated energetic electrons into interplanetary space. The beam of energetic electrons, interacting with the surrounding plasma as it propagated, produced electromagnetic waves at the local plasma frequency in the kHz - MHz range. This type III radio burst has been observed by various spacecrafts and on Earth.

RPW and its SCM search coil magnetometer measured the magnetic component of the electromagnetic wave at frequencies between 140 kHz and 450 kHz. To our knowledge, this is the first detection in space of the magnetic signature of a radio wave which is not emitted by a planet. These measurements allow to estimate the refractive index of the wave, and to discuss the wave mode and the direction of the wave vector.

O47: C.M.S. Cohen – Using Multiple Spacecraft Observations in the 28 October 2021 SEP Event to Test Models

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The first ground level enhancement (GLE) event of solar cycle 25 was observed by Parker Solar Probe (PSP), Solar Orbiter, STEREO-A (STA), and Advanced Composition Explorer (ACE). The spacecraft were spread over 60° in longitude and almost 0.4 AU radial distance from the Sun. The measured O and Fe spectra and composition was strikingly uniform between PSP, STA, and ACE over approximately an order in magnitude in energy. Simulations suggest this may be due to a serendipitous similarity in the shock parameters at the magnetic connection points of the three spacecraft. Solar Orbiter was connected to the shock where the properties differed significantly. Under the assumption that the shock properties dominate the observed SEP characteristics, this suggests the Solar Orbiter spectra and composition should be markedly different. We present these observations, the modeling results and discuss their implications.

O48: Elena Petrova – High frequency oscillations in Solar Orbiter/EUI observations

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High-frequency wave phenomena present a great deal of interest as one of the possible candidates to contribute to the energy input required to heat the corona as a part of the AC heating theory. However, the resolution of imaging instruments up until the Solar Orbiter have made it impossible to resolve the necessary time and spatial scales. The present paper reports on high-frequency transverse motions in a small loop located in a quiet Sun region of the corona. The oscillations were observed with the HRIEUV telescope (17.4 nm) of the EUI instrument onboard the Solar Orbiter. We detect two transverse oscillations in short loops with lengths of 4.5 Mm and 11 Mm. The shorter loop displays an oscillation with a 14 s period and the longer a 30 s period. Despite the high resolution, no definitive identification as propagating or standing waves is possible. The velocity amplitudes are found to be equal to 72 km/s and 125 km/s, respectively, for the shorter and longer loop. Based on that, we also estimated the values of the energy flux contained in the loops - the energy flux of the 14 s oscillation is 1.9 kW m^{-2} and of the 30 s oscillation it is 6.5 kW m^{-2} . While these oscillations have been observed in the Quiet Sun, their energy fluxes are of the same order as the energy input required to heat the active solar corona. Numerical simulations were performed in order to reproduce the observed oscillations. The correspondence of the numerical results to the observations provide support to the energy content estimates for the observations. Such high energy densities have not yet been observed in decayless coronal waves, and this is promising for coronal heating models based on wave damping.

O49: Shaheda Begum Shaik – The SoloHI Observations on SEP producing CMEs: Flare-CME-SEP Connection

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The role of particle acceleration from flares and coronal mass ejections (CMEs) on the origin of SEP (solar energetic particles) seed particles and the connection between flares-CMEs and SEPs are still unclear. We present the preliminary analysis from an initial set of the SEP-producing CMEs observed on 10 March and 30 March 2022 by the Solar Orbiter Heliospheric Imager (SoloHI) onboard the Solar Orbiter mission.

Some CME events do not produce SEPs even though they generate a shock, and some large reconnection events that lack shock waves have flares but do not produce SEPs, showing event-to-event variation. Recent observations from radio instruments like Expanded Owens Valley Solar Array (EOVSA) have shown a new perspective of the standard flare model, having a flaring region with a large spatial scale of low-frequency microwave emission. These flares have shown that the accelerated particles can be transported to a much larger volume than observed at other high-energy wavelengths. When flares and CMEs generate such a large spatial extent of accelerated particles, do they have any unexplored contribution to create the seed particles? If yes, how can event-to-event variations explain the SEP conditions?

To answer these questions, heliospheric imaging from SoloHI can provide crucial information on the accelerated particles that can be smeared during the transport to the distant 1 AU in-situ observations. SoloHI imaging can resolve CME-associated shocks and probe the regions crucial for understanding the connection to the heliospheric and coronal magnetic field configurations. We study the correlation interplay between event parameters and verify the SEP conditions from joint observations of the Solar Orbiter, Parker Solar Probe (PSP; WISPR-FIELDS-IS$\odot$IS), EOVSA, STEREO, and SOHO. This study will address the respective contributions of seed populations from the flare magnetic reconnection and CME-associated shock accelerations.

O50: Miho Janvier – Solar Orbiter and the solar/heliospheric fleet coordinated observations of a filament eruption: a test bed for a global eruptive flare model

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Eruptive solar events can lead to the formation and the expulsion of large-scale magnetic structures in the interplanetary medium, called coronal mass ejections (CMEs), as well as, the acceleration and injection of particles within the heliosphere. CMEs transport solar plasma and magnetic field in the solar system; along with high energy particles, they can interact with the space environment of planets. It is critical to improve our understanding of how these drivers of space weather evolve, from their initiation at the Sun's outer atmosphere, the corona, to their propagation in the interplanetary space. However, while CMEs and high energy particles are routinely measured remotely and in situ by spacecraft dedicated to observe the Sun and the solar wind, so far our measurements have been restricted to few positions close to 1 au and near the ecliptic.

In the first remote-sensing campaign of its nominal phase, Solar Orbiter and the heliophysics fleet of other solar missions (SDO, SoHO, Hinode, IRIS and STEREO-A) were ideally placed to observe simultaneously, and from different vantage points, eruptive solar events occurring on April 2nd 2022 and its accompanying CME detected in situ a few hours later. In this presentation, we will review first the unprecedented wealth of data covering the pre-eruption phase, to the eruption and early coronal propagation, the high energy particles and plasma waves detections and, finally, the in situ measurements of the CME detected directly by Solar Orbiter. We will then focus on the solar wind connectivity and CME/shock propagation to understand the timings, features and the widespread nature of high energy particles and plasma waves detected by several spacecraft.

By providing simultaneous observations at different positions in the inner solar system, Solar Orbiter and the other spacecraft can now help us integrate models of eruptive flares and CMEs and energetic particles into one global solar eruption model linking the Sun's atmosphere to the inner heliosphere. The April 2nd 2022 eruptive event also provides a great example of the capabilities of joint observation campaigns and what is next for the future observation windows of the Solar Orbiter nominal mission.

O51: Nawin Ngampoopun – The evolution of an erupting filament and the South Polar Coronal Hole boundary during Solar Orbiter's First Perihelion

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In this work, we report a southern hemisphere filament eruption that occurred on 2022 March 18, during the first perihelion of Solar Orbiter. The filament erupted as a coronal mass ejection (CME), producing transient dimmings at the footpoints of the erupting structure. The eruption, and its associated expanding magnetic field, appear to have modified the structure of the adjacent southern polar coronal hole, producing a merged coronal hole/CME dimming region. This work aims to understand the physical processes triggered by the filament eruption, which led to the merger of the CME dimming region and coronal hole. These processes could be related to how magnetic reconnection driven by a CME can open magnetic field lines to interplanetary space and impact the solar wind. We use remote sensing data from multiple co-observing spacecraft to study the southern polar coronal hole and CME dimming merger. In particular, the evolution of the merging process is examined using Extreme-UltraViolet (EUV) images obtained from the Extreme Ultraviolet Imager instrument onboard Solar Orbiter and Solar Dynamic Observatory spacecraft. The plasma evolution is then quantified using EUV spectroscopic data obtained from the EUV Imaging Spectrometer onboard Hinode. This work aims to advance our understanding of magnetic and plasma evolution at coronal hole boundaries, which could have important impacts on the origin of the solar wind.

O52: Gabriel Pelouze – Thermal non-equilibrium: a probe for coronal heating in the Solar Orbiter era

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Thermal non-equilibrium (TNE) produces several observables that can be used to constrain the spatial and temporal distribution of coronal heating. Its manifestations include prominence formation, coronal rain, and long-period intensity pulsations in coronal loops. TNE is thus ubiquitous over a wide range of structures, temperatures, and densities. For these reasons, it has become a key tool for confronting models of coronal heating with observations. I will present recent developments in the simulation of TNE, and the observation of its consequences. Then, I will discuss how new observations from Solar Orbiter can advance our understanding of TNE, and constrain coronal heating mechanisms.

O53: Lakshmi Pradeep Chitta – Solar coronal heating from small-scale magnetic braids

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Relaxation of braided coronal magnetic fields through reconnection is thought to be a source of energy to heat plasma in active region coronal loops. However, observations of active region coronal heating associated with untangling of magnetic braids remain sparse. One reason for this paucity could be the lack of coronal observations with sufficiently high spatial and temporal resolution to capture this process in action. Using new high spatial resolution (250-270 km on the Sun) and high cadence (3-10 s) observations from the Extreme Ultraviolet Imager (EUI) on board Solar Orbiter we observed untangling of small-scale coronal braids in different active regions. The untangling is associated with impulsive heating of the gas in these braided loops. We assess that coronal magnetic braids overlying cooler chromospheric filamentary structures are perhaps more common. Furthermore, our observations show signatures of both spatially coherent and intermittent coronal heating during relaxation of magnetic braids. Our study reveals the operation of both more gentle and explosive modes of magnetic reconnection in the solar corona. In this talk, we will present these new EUI observations and discuss the implications for magnetic braiding associated coronal heating.

O54: Elisabeth Werner – Solar Orbiter observations of waves and turbulence inside magnetic clouds

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Interplanetary coronal mass ejections (ICMEs) often contain large-scale magnetic structures which are identified in in-situ plasma and field measurements by an enhanced magnetic field strength, smoothly changing magnetic cone and/or clock angles and a low plasma beta. These magnetic flux ropes, which are also known as magnetic clouds (MCs), have been shown to be particularly effective in driving magnetospheric disturbances at Earth. In recent years, the connection between the large-scale structure of the MC observed in-situ and remote coronographic and EUV observations of the solar source has been well studied in literature, much due to its importance for forecasting ICME-driven geomagnetic storms. The prevalence of waves, nature of the turbulence inside MCs and small-scale field and plasma structures inside MCs, which result from interaction with the ambient solar wind and interplanetary transients such as other ICMEs, stream interaction regions (SIRs) and the heliospheric plasma sheet (HCS), are less well-understood, and particularly their importance for the geoeffectiveness of the overall structure. The plasma and field measurements by Solar Orbiter permit us to study waves, turbulence and ion-scale substructures inside the MCs with unprecedented resolution. We study the waves and turbulence inside MCs observed by Solar Orbiter using data from RPWI, MAG and PAS. We compare observations of MCs at different radial distances and their evolution in the heliosphere through coordinated spacecraft observations with Wind, STEREO-A and Parker Solar Probe.

O55: Yuri Khotyaintsev – Electromagnetic Ion-Cyclotron Waves Observed by Solar Orbiter

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Waves and low-frequency turbulence are common in the solar wind. We use Solar Orbiter to investigate electromagnetic circularly-polarised waves near the proton cyclotron frequency. Such waves given their frequency are thought to play an important role in shaping the ion velocity distribution functions in the solar wind. We study the occurrence of the waves in the first two years of the Solar Orbiter observations at varying distances from the Sun. We present detailed observations of ion velocity distributions observed simultaneously with the waves, and analyse related growth and damping of the waves. We also compare the Solar Orbiter observations to the similar observations by MMS.

O56: Lucia Abbo – Structure and dynamics of the coronal streamer belt by Solar Orbiter/Metis observations

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Since its launch in February 2020 Solar Orbiter has provided novel observations of the coronal streamer belt with unprecedented quality and from a completely new perspective given its peculiar orbital profile. In particular, the Metis coronagraph has observed the solar corona for the first time with global images simultaneously in the visible light and ultraviolet bands providing measurements of the K-corona polarised and total brightness and of the neutral hydrogen Lyman-α line intensity. Using Metis observations of the streamer belt together with EUI images of both solar disk and corona (taken using an external occulter), we can trace features from the extended corona back to the disk. This kind of joint observations may allow to better characterise the physical structure and properties of the slow solar-wind sources. Moreover, Metis visible-light observations acquired at both high spatial resolution and low temporal cadence during the first close approach of Solar Orbiter to the Sun in March 2022, give us new possibilities of studying in greater detail the fine structure and dynamics of the large-scale coronal streamer belt.

O57: Giuseppe Emanuele Capuano – Solar corona diagnostics with Metis observations

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The solar corona has been investigated in the last decades through observations coming from several spacecraft. The Metis coronagraph, aboard the ongoing Solar Orbiter mission, extends the UVCS/SOHO spectrocoronagraph observations of the scattered ultraviolet emission of the coronal plasma performed during solar activity cycle 23, by simultaneously imaging the coronal polarised visible light (pB), in the spectral bandpass 580-640 nm, and the coronal ultraviolet HI Lyα emission, in the spectral window 121.6 ± 10 nm. We present here some specific observations, such as those taken on May 15, 2020, from which high temporal and spatial resolution maps of the coronal outward velocity were calculated by applying the Doppler dimming technique. Other results on the coronal solar wind outflow velocity were obtained by considering the quadrature of Solar Orbiter and PSP with respect to the Sun, when the same parcel of plasma was observed remotely with Metis between 3.5 and 6.3 solar radii on January 17, 2021 on the East limb and in situ by PSP at 22 and 56 solar radii on January 18 and 23, 2021, respectively. In this case, information on several coronal parameters were obtained with unprecedented details, thanks to the high quality PSP data. Finally, other results concern the first CME observed with Metis on January 16-17, 2021 and a CME with an associated prominence eruption (followed by a plasma blob) observed on February 12, 2021, while operating in synoptic mode. In these cases, considering data coming from instruments onboard other spacecraft and on Solar Orbiter, a 3D reconstruction and physical information of these structures were obtained. Therefore, Metis, even when operate in low cadence synoptic mode in synergistic coupling with other instruments, allows to get novel and detailed information on the structure of the solar corona with an accuracy never reached until now.

O58: Andreas J. Weiss – Inferring global ICME properties using multi-point in-situ magnetic field observations

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We present our latest results, using forward modelling techniques, that allow us to reconstruct the in-situ magnetic field observations of well-behaved ICMEs. The same techniques can also be applied to reconstruct events that were captured by multiple spacecraft. These multi-point observations potentially allow us to infer global ICME properties that cannot be deduced by single-point observations. Of specific interest are the flux rope twist or the ICME height which, under favorable spacecraft separations, can be accurately inferred within the framework of our model by using only two separate spacecraft. Analysis of recent observations, including events captured by Solar Orbiter, are given as examples.

O59: Robin Colaninno – The Solar Orbiter Heliospheric Imager (SoloHI) for the Solar Orbiter Mission: First Science Observations and Instrument Status

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The SoloHI instrument has completed its first science operations after the nominal cruise phase of the Solar Orbiter mission. The mission, launched in February 2020, underwent gravity assist manoeuvres around Venus and Earth during the cruise phase to reach the first science perihelion distance of 0.32 AU. The mission will continue to undergo Venus gravity assist manoeuvres to change both the perihelion distance as well as the plane of the orbit to ultimately achieve a minimum perihelion of 0.28 AU and an orbital inclination of about 35° relative to the ecliptic plane. The remote sensing instruments had science observations for three 10-day periods around perihelion during the nominal 6-month orbit. SoloHI and the other remote sensing instruments have had extended periods of lower cadence synoptic observations, in addition to the baseline science observations in the remote sensing windows. SoloHI detects sunlight scattered by free electrons in the corona and solar wind from 5° to 45° elongation in visible wavelengths, providing linkage between solar and solar wind observations. The science investigation focuses on the solar wind, including streamers, small-scale intensity and density fluctuations, jets, and Coronal Mass Ejections (CMEs). SoloHI is very similar to the HI-1 instrument on STEREO/SECCHI and the WISPR instrument on PSP with different FOVs and orbital distances. We present SoloHI early observations including the instrument status, our science planning strategy, our observing plans, calibration, early science and our low-latency and science data products.

O60: Emma Davies – Using In-Situ Multi-Spacecraft and Remote Imaging Observations to Understand the Evolution of Interplanetary Coronal Mass Ejections

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Interplanetary coronal mass ejections (ICMEs) are the main drivers of severe space weather at Earth and thus understanding their evolution is of great interest in space weather modelling and arrival prediction at various targets throughout the solar system. To better understand ICME evolution in-situ, it is useful to track signatures of specific ICMEs over large heliocentric distances whilst spacecraft are close to radial alignment. Such studies of ICMEs provide valuable insight into their properties, structure, and expansion as they propagate through the heliosphere.

Combining in-situ and remote observations with various flux rope modelling techniques aids in determining the global structure of an ICME as it propagates. We present observations of an ICME observed by Solar Orbiter, Wind and Bepi-Colombo, and compare with other multi-spacecraft events observed beyond 1 AU by the Juno spacecraft. By tracking individual events back to the inner heliosphere, we use multi-spacecraft observations to assess their global and local expansion as they propagate, demonstrating the large variability of individual ICME properties and deviations from statistical relationships. We highlight the importance of the interplanetary environment in which the ICME propagates and explore how interactions with other solar wind features may affect ICME evolution.

O61: Frédéric Auchère – Solar Orbiter/EUI/FSI very wide field observations of the EUV corona.

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At 3.8°, the field of view (FOV) of the Full Sun Imager (FSI) on Solar Orbiter is by far wider than that of any previous solar EUV imager. Depending on the distance of the probe to the Sun along its orbit, this corresponds to 14 to 4 solar radii, to be compared to the 3.5 Rs of STEREO/EUVI or Proba2/SWAP. This very large field of view opens up a new discovery space into a region largely unexplored in the EUV. Since it was expected that stray-light would dominate beyond 2 Rs, a moveable occulting disk can be inserted in the optical path to block light rays up to 0.78° off the optical axis. On March 21 2021, at 0.51 AU, FSI acquired deep exposures at 17.4 and 30.4 nm with the occulting disk in place. The data reveals solar structures extending up to 5 Rs which, to our knowledge, is the furthest ever recorded at these wavelengths. We present a comparison of the measured signal fall-off as a function of distance to Sun-center with a model of coronal emission taking into account collisional excitation and resonant scattering. The presence of resonant scattering off disk at 17.4 nm is predicted, but is so far not confirmed by observations. If confirmed, this resonantly scattered component can have implications on plasma diagnostics that assume line formation by collisional excitation.

O62: Morgan Stores – X-ray Diagnostics of Spatially Extended Turbulent Electron Acceleration and Transport in Solar Flares

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Solar flares are effective particle accelerators, with as much as 10-50% of the $<10^{33}$ ergs of energy released from magnetic reconnection contributing to accelerating particles to energies greater than 20 keV. However, the properties and location of the acceleration region is largely unknown with competing theories of the acceleration mechanism, including acceleration by turbulence. The imaging spectroscopy abilities of RHESSI, and now STIX onboard Solar Orbiter (SolO), have provided spatially resolved X-ray spectra from bremsstrahlung-emitting electrons accelerated during flares. Thus, hard X-ray emission has been a vital tool in determining the properties of flare accelerated electrons at the Sun. In order to constrain the properties of the acceleration region itself, a time independent Fokker-Planck equation is used to describe the transport of energetic electrons through a coronal plasma of finite temperature, accounting for collisions as electrons are transported along the guiding magnetic field. Furthermore, an extended turbulent acceleration region is incorporated into the model, driven by recent non-thermal line broadening observations (Hinode EIS) suggesting extended regions of turbulence, and possibly acceleration in the loop apex and loop itself. To determine how different acceleration environments (i.e. varying acceleration timescale, spatial extent of the acceleration region, spatial distribution of turbulence) change observed accelerated electron properties we produce outputs for the density weighted electron spectrum modelled in energy, pitch angle and space from the corona to chromosphere. Using our simulation results, I will discuss several useful X-ray spectral and imaging diagnostics which can be compared directly to archived RHESSI and new STIX observational data, helping to constrain the properties of solar flare acceleration in individual flares.

O63: Gherardo Valori – Stereoscopic disambiguation of vector magnetograms: first applications to SO/PHI-HRT data

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Spectropolarimetric reconstructions of the photospheric vector magnetic field are intrinsically limited by the 180° ambiguity in the orientation of the transverse component. The successful launch and operation of Solar Orbiter (SO) have made the removal of such an ambiguity possible using solely observations obtained from two different vantage points. The basic idea is that the unambiguous line-of-sight component measured by one vantage point will generally have a non-zero projection on the ambiguous transverse component measured by the second instrument. In this way, the “true” orientation of the measured transverse component can in principle be identified directly from observations without any additional hypotheses or modelling.

The Stereoscopic Disambiguation Method (SDM) was recently developed and tested using numerical simulations (Valori et al. Sol. Phys. 297:12, 2022). In this presentation I will briefly explain the SDM and present a first application to data obtained by SO/PHI-HRT during the March 2022 campaign, when the angle between SO and the Solar Dynamic Observatory (SDO) was 27°. The SDM is successfully applied to remove the ambiguity of the transverse component of the SO/PHI-HRT vector magnetogram using SDO/HMI observations, and vice versa, for the first time. A short discussion about the challenges that may limit the accuracy of the SDM is also presented.

O64: Daniele Telloni – Observation of Magnetic Switchback in the Solar Corona

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Switchbacks are sudden, large radial deflections of the solar wind magnetic field, widely revealed in interplanetary space by the Parker Solar Probe. The switchbacks' formation mechanism and sources are still unresolved, although candidate mechanisms include Alfvénic turbulence, shear-driven Kelvin-Helmholtz instabilities, interchange reconnection, and geometrical effects related to the Parker spiral. This Letter presents observations from the Metis coronagraph onboard Solar Orbiter of a single large propagating S-shaped vortex, interpreted as first evidence of a switchback in the solar corona. It originated above an active region with the related loop system bounded by open-field regions to the East and West. Observations, modeling, and theory provide strong arguments in favor of the interchange reconnection origin of switchbacks. Metis measurements suggest that the initiation of the switchback may also be an indicator of the origin of slow solar wind.

O65: Ronan Laker – Multi-spacecraft study of the Solar Wind in Latitude

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Solar Orbiter's launch in Feb 2020 has helped create a constellation of spacecraft in the inner heliosphere which also includes Parker Solar Probe, BepiColombo, STEREO-A and the spacecraft at L1. We will explore how such a constellation of spacecraft can create novel opportunities for alignments, which can then be used to probe how the solar wind changes in time, longitude, latitude and distance from the Sun. In this talk, we will explore how differences in spacecraft latitude can be used to map the shape of the Heliospheric current sheet and co-rotating interaction regions. We find that even small changes of a few degrees in latitude can drastically alter the conditions experienced by the spacecraft. Specifically, we demonstrate that STEREO-A was 7 degrees lower in latitude and saw the compression region created by an interaction region, but missed the faster solar wind itself. We will also investigate potential new opportunities to study the large scale structure of the solar wind with this set of spacecraft, and how Solar Orbiter's inclined orbit could help.

O66: Adam J. Finley – Rotation of the Solar Corona and Solar Wind Angular Momentum-loss

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The rotational-state of the solar corona is challenging to decipher, and is nearly impossible to directly measure. Understanding coronal rotation is vital for multiple topics of ongoing research, ranging from studies of solar wind connectivity (to the various Heliospheric spacecraft), to studies of the rotation-evolution of Sun-like stars. Stars like the Sun efficiently shed angular momentum via magnetized stellar winds. These winds remove a relatively miniscule mass-flux, but the presence of a large-scale stellar magnetic field acts to exchanges angular momentum with the outflowing plasma out to large distances. With Parker Solar Probe (PSP) now sampling the solar wind at "sub-alfvenic" distances (less than 15Rsun), it has become clear that the rotation of the solar corona is more structured and dynamic that previously thought, with large tangential flows of up to 50km/s detected in the near-Sun environment. Differences between current magnetohydrodynamic models of the solar wind rotation, and that measured by PSP are likely linked to the transport of angular momentum from the photosphere into the low-corona and beyond. The rotational state of the "coronal base" is heavily debated, and will likely remain uncertain. However, with the wealth of new Heliospheric missions/observatories (PSP, Solar Orbiter, DKIST, Vigil,…), and existing infrastructure (SOHO, STEREO-A, SST,...), we may soon be able to constrain the rotation of the solar corona/wind, and subsequently apply this knowledge to the coronae of other Sun-like stars. This includes measuring more precisely the angular momentum-loss rate of the current Sun, in comparison to that predicted by models of rotation-evolution (for which the rotation period-evolution of Sun-like stars at, or older than, the age of the Sun, is current highly debated).

O67: Ruggero Biondo – Connecting Solar Orbiter remote-sensing observations and Parker Solar Probe in-situ measurements with a numerical MHD reconstruction of the Parker spiral

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A key feature of NASA's Parker Solar Probe (PSP) and ESA-NASA's Solar Orbiter (SO) missions is their cooperation, allowing to trace solar wind and transient from their sources on the Sun to the inner interplanetary space, in order to understand their emergence and evolution.

Goal of this work is to accurately reconstruct the interplanetary Parker Spiral and the connection between coronal features observed remotely by the Metis coronagraph on-board SO and those detected in-situ by PSP at the time of the first PSP-SO quadrature of January 2021.

We use the Reverse In-situ and MHD Approach (RIMAP), a hybrid analytical-numerical method performing data-driven reconstructions of the interplanetary Parker Spiral. RIMAP solves the MHD equations on the equatorial plane with the PLUTO code, using the measurements collected by PSP between 0.1 and 0.2 AU. Our reconstruction connects density and wind speed measurements provided by Metis (3-6 solar radii) to those acquired by PSP (21.5 solar radii) along a single streamline.

The capability of our MHD model to connect for the first time the inner corona observed by Metis and the super alfvénic wind measured by PSP, not only confirms the research pathways provided by multi-spacecraft observations, but also the validity and accuracy of RIMAP reconstructions as a possible test bench to verify models of transient phenomena propagating across the heliosphere, such as coronal mass ejections, solar energetic particles and solar wind switchbacks.

O68: Raffaella D'Amicis – On the Alfvénic slow wind: origin and evolution

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Solar wind turbulence dominated by large-amplitude Alfvénic fluctuations, mainly propagating away from the Sun, is ubiquitous not only in high-speed solar wind streams but also in some slow wind intervals. Indeed, the Alfvénic slow wind has been observed at different heliocentric distances in the inner heliosphere and has been found to share several properties with the fast streams. This includes a similar solar source, identified as a region of strongly diverging open magnetic field such as low latitude isolated coronal holes and/or the boundaries of the polar coronal holes. The over-expansion of the magnetic field lines may have an impact on the slowing down of this solar wind regime thus contributing to our understanding of the general problem of solar wind acceleration. This topic is particularly relevant to observations performed during periods of high solar activity, which have been found to have a statistically large incidence of this solar wind regime. In this study, in particular, we will show several observations of the Alfvénic slow wind performed by Solar Orbiter, Parker Solar Probe and Wind at L1 that will offer an unprecedented opportunity to investigate the origin and evolution of the Alfvénic content of the solar wind fluctuations in the inner heliosphere, focusing on its dependence on scale and on the heliocentric distance.

P1: Lucas Colomban – Using Solar Orbiter and Parker Solar Probe to assess the role of whistler waves in the shaping of the solar wind electron distribution function

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In the solar wind, the electron distribution function is composed of different populations: a Maxwellian core, a suprathermal halo and a beam aligned with the magnetic field called "Strahl". The proportion of the suprathermal populations varies surprisingly with distance, which is probably due to wave-particles interactions.

Whistler waves, electromagnetic waves around 0.1 fce, may play an important role in the evolution of these populations, in particular by diffusing the particles in pitch angle (angle between the DC magnetic field and the electron velocity). However, there is no definitive evidence that whistler waves are sufficiently present or that diffusion is actually at work. To assess the role of whistler waves, we first analysed data from Solar Orbiter and Parker Solar Probe between 0.17 and 1 AU to detect and characterise the waves, in the plasma frame and as a function of distance and solar wind speed. We then calculated the diffusion coefficients for different properties of the waves. The diffusion coefficients are calculated in the framework of quasi-linear theory and represent the ability of the wave to diffuse an electron. This allowed us to determine which parameters are effective for the diffusion and its evolution between 0.17 and 1 AU.

P2: Gabriel Pelouze – Full-Sun observation of chromospheric and coronal lines by SPICE

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We present four SPICE full-Sun intensity maps of lines H I Ly β 1025 Å, C III 977 Å, O VI 1032 Å, and Ne VIII 770 Å. In particular, we show the first full-disk image of H I Ly β since OSO-8 (1975-1984), with a significant increase in spatial resolution. These maps were obtained during the Sun-Earth conjunction on 7 March 2022 (distance 0.49 au), and combine 25 rasters using the 30-arcsec-wide slit of SPICE. We derived the irradiance integrated over the disk, as well as the centre-to-limb variation for these lines. By comparing to observations from SDO/EVE, we can provide constraints on the radiometric calibration of SPICE. Furthermore, the center-to-limb variation can be used for constraining atmosphere models, as well as linking future disk-center measurements to the irradiance.

P3: Ronan Laker – Real time CME forecasting using Solar Orbiter:

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Space weather can create significant damage/disruption on Earth, much of which can be mitigated with a prior warning. This is normally provided by remote sensing data, which estimates the initial parameters and produces a prediction of the arrival time. However, this cannot give an accurate prediction for the internal magnetic structure, which is crucial for determining the geo-effectiveness of the CME. Mission concepts for an upstream solar wind monitor at 0.5AU have been proposed, but require currently inaccessible solar sail technology. Fortunately, Solar Orbiter had a rare opportunity to emulate this future concept in March 2022, when it crossed the Sun-Earth line at 0.5AU. Thanks to the work of the MAG team, we were able to see almost real time magnetic field measurements, allowing us to predict the arrival and magnetic structure of two CMEs up to a day in advance. The magnetic structure and arrival times were accurate between Solar Orbiter and L1 measurements, proving the efficacy of an upstream solar wind mission. In addition, we assessed the prediction capabilities for the ambient solar wind, which was also accurate, and could be used to predict the arrival of co-rotating interaction regions, which can also drive space weather at Earth. Finally, we look ahead to April 2023 when this opportunity will repeat, with the Sun closer to solar maximum.

P4: Jonas Sinjan – SO/PHI-HRT SDO/HMI Cross-Calibration and the True Solar Magnetic Flux

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Onboard the Solar Orbiter spacecraft is the Polarimetric and Helioseismic Imager (SO/PHI), which has two telescopes, a high resolution telescope (HRT) and the full disk telescope (FDT). The instrument is designed to infer the photospheric magnetic field through differential imaging of the polarised light emitted from the Sun. It is the first magnetograph to move out of the Sun-Earth Line, providing excellent stereoscopic opportunities with other ground and space based instruments. Of particular interest is the correlation between SO/PHI and SDO/HMI, since they probe the same magnetically sensitive line of Fe1: 6173Å. Here a cross correlation between HMI and HRT is presented using conjunction data from the Cruise and Nominal Mission Phase(s).

Secondly, a possible contributor to the Open Flux problem is the underestimation of polar magnetic flux. As a pre-study to investigating this with stereoscopic data from PHI, simulations were carried out to understand the underlying physics when viewing the magnetic field at highly inclined viewing angles ($\mu=\cos(\Theta)$). MuRAM simulations together with SPINOR inversions were used to generate Stokes profiles over a range of μ. Results from these simulations into the μ dependence of the magnetic flux will be shown.

P5: James Stewart – Oscillatory reconnection and waves driven by merging magnetic flux ropes in solar flares

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Oscillatory reconnection is a process that has been suggested to underlie several solar and stellar phenomena and is likely to play an important role in transient events such as flares. Quasi-periodic pulsations (QPPs) in flare emissions may be a manifestation of oscillatory reconnection, but the underlying mechanisms remain uncertain. In this talk, I introduce the concept of magnetic reconnection and present 2D magnetohydrodynamic (MHD) simulations of two current-carrying magnetic flux ropes with an out-of-plane magnetic field undergoing oscillatory reconnection in which the two flux ropes merge into a single flux rope.

I discuss how these flux ropes merge intrinsically without an external oscillatory driver which may occur both during large-scale coronal loop interactions and the merging of plasmoids in fragmented current sheets. Furthermore, I will discuss the presence of radially propagating non-linear waves that are produced in the aftermath of the merging process that may be associated with QPPs.

P6: Camille Yasmina Lorfing – What energy electrons interact with Langmuir waves at different distances from the Sun?

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Solar electrons beams are accelerated in the corona, and can travel out into the solar wind and beyond. These beams of non-thermal electrons evolve as a function of distance from the Sun, interacting with the background plasma and growing Langmuir waves as they propagate. Subsequent radio emission is also seen in the form of type III bursts. Around 1 AU, when we detect in- situ electron beams, only electrons up to 10-20 keV are detected together with local Langmuir waves. Higher energy electrons arrive beforehand. However, previous studies suggest that these higher energy electrons interact with Langmuir waves close to the Sun and therefore would not propagate scatter-free, as typically assumed. Through beam-plasma structure simulations we study the interactions between solar electron beams and the background plasma of the solar corona and the solar wind at different distances from the Sun, up to 50 solar radii. This allows us to determine what is the maximum electron velocity responsible for Langmuir wave production and growth, and consequently which electron energies are affected by wave-particle interactions as a function of distance from the Sun. We also vary the spectral index of the electron velocity distribution and the electron beam density to identify what role they play in determining the relevant electron velocities at which wave-particle interactions occur. Understanding the mechanisms driving the change in the maximum electron velocity will permit more accurate predictions in electron onset as well as arrival times, relevant for space weather applications and the understanding of the subsequent emissions at radio and X-ray wavelength. Moreover, our radial predictions can be tested against in-situ electron and plasma measurements from the instruments on-board the Solar Orbiter and Parker Solar Probe spacecrafts.

P7: Shaun A. Mclaughlin – Radiative Hydrodynamic Modelling of the Lyman Continuum during Solar Flares

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The Lyman Continuum (LyC; <912Å) forms at the base of the transition region in the quiet-Sun, as a result of a free-bound transition, making LyC a powerful tool for probing the chromospheric plasma conditions during solar flares. By fitting the LyC spectrum applying an Eddington-Barbier approximation, the departure coefficient of hydrogen, b1, and the colour temperature, Tc, can be determined. The departure coefficient measures the degree to which the plasma departs from local thermodynamic equilibrium and has been observed to approach unity during flares, indicating a strong coupling to local conditions. When b1 approaches unity, Tc is reflective of the electron temperature of the plasma. To understand the effects of nonthermal energy deposition in the chromosphere during solar flares, we have been analysing LyC profiles from a grid of 1D field-aligned radiative hydrodynamic RADYN models hosted at Queen's University Belfast, which were generated as part of the F-CHROMA project. We have investigated the spectral response of LyC, and the temporal evolution of b1 and Tc in response to a range of nonthermal heating functions, based on characteristic electron fluxes, spectral indices, and low-energy cutoffs. The LyC intensity was seen to increase by 3-5 orders of magnitude during solar flares, responding strongly to the electron flux of the beam. Generally, b1 decreased from $10^{2\text{-}3}$ to approximately 1 during solar flares, while Tc increased from ~8000K to ~12000K. By generating continuum contribution functions, we found that there are both optically thick and thin components of LyC, in agreement with observations. The optically thick layer forms ~1000km deeper in the chromosphere during a flare compared to quiescent periods, and is strongly coupled to local conditions. The optically thin layers form at higher altitudes due to chromospheric evaporation. Whether the evaporation is explosive or gentle affects the number of optically thin layers formed.

P8: Frederic Schuller – The STIX Aspect System and Solar Orbiter's pointing stability

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The Spectrometer/Telescope for Imaging X-rays (STIX) has been delivering images in thermal and non-thermal X-ray emission since April 2020. Because only flaring regions are visible in hard X-rays, no other solar features that are conventionally used for co-alignment (e.g. the solar limb) can be used to assess the pointing. Moreover, thermoelastic deformation of the spacecraft or STIX mechanical structures can change the relative direction of the STIX optical axis in the spacecraft reference frame, so that relying on the spacecraft aspect solution alone does not provide the required accuracy to place STIX images in the context of data acquired at other wavelengths. Therefore, a dedicated optical system, the STIX Aspect System (SAS), was specifically designed to measure the pointing direction of STIX with respect to the Sun. Here we provide a description of the system and an overview of the results obtained so far, which demonstrate how the SAS measurements can help improving the pointing stability of Solar Orbiter over the course of the mission.

P9: Yajie Chen – Investigating Campfires and Their Relationship to Transition Region Explosive Events

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Recent observations by the Extreme Ultraviolet Imager (EUI) onboard Solar Orbiter have revealed prevalent small-scale transient brightenings in the quiet solar corona termed "campfires". To understand the generation mechanism of these coronal brightenings, we constructed a self-consistent and time-dependent quiet-Sun model extending from the upper convection zone to the lower corona using a realistic three-dimensional radiation magnetohydrodynamic simulation. From the model we have synthesized the coronal emission in the EUI 174 Å passband. We identified several transient coronal brightenings similar to those in EUI observations. The size and lifetime of these coronal brightenings are mostly 0.5-4 Mm and 2 min, respectively. These brightenings are generally located at a height of 2-4 Mm above the photosphere, and the local plasma is often heated above 1 MK. By examining the magnetic field structures before and after the occurrence of brightenings, we concluded that these coronal brightenings are generated by component magnetic reconnection between interacting bundles of magnetic field lines or neighboring field lines within highly twisted flux ropes. Occurring in the coronal part of the atmosphere, these events generally reveal no obvious signature of flux emergence or cancellation in photospheric magnetograms. These transient coronal brightenings may play an important role in the heating of the local coronal plasma. Furthermore, we synthesize spectral profiles of the Si IV 1394 Å lines from the model. All seven campfires in our model show enhanced Si IV emissions, and most of them exhibit non-Gaussian Si IV line profiles. On the other hand, many explosive events do not show any coronal signature in the synthesized EUI 174 Å images. Therefore, campfires often occur together with transition region explosive events, but the released energy around most explosive events is insufficient to heat the plasma there to 1 MK.

P10: Charlotte Proverbs – Automatic Identification and Tracking of Sunspots

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It is well understood that sunspot dynamics lead to energy being stored in the solar atmospheric magnetic field. The driving mechanisms for this energy generation may include sunspot rotations, both within individual sunspots and between sunspot pairs. Identification and tracking of sunspots is therefore essential to understanding the energies in play that lead up to solar eruptions. In this poster I will outline the progress that has been made so far with the automatic sunspot detection and tracking algorithm. Case studies of successfully tracked sunspots will be demonstrated, showing some initial results of sunspot rotation calculations and dynamics.

P11: Hualin Xiao – Exploring the Impact of Solar Energetic Particles in STIX Hard X-ray Observations

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The Spectrometer Telescope for Imaging X-rays (STIX) is one of the ten instruments onboard Solar Orbiter. It measures X-rays emitted during solar flares in the energy range of 4 – 150 keV, and takes X-ray images by using an indirect imaging technique, based on the Moiré effect. Thirty-two pixelated CdTe detectors with a total effective area of 6 cm^2 are used by STIX to measure X-rays. Apart from X-rays, solar energetic charge particles can also be recorded by STIX detectors, which can contaminate hard x-ray observations. Due to the grids and X-ray windows in front of the detectors, as well as the enclosure, only particles of above certain energies can reach STIX detectors. In this study, we present simulations of STIX response to solar energetic charge particles. Several SEP events are simulated and compared with observations from STIX and the in situ particle detector suite EPD.

P12: Antoine Dolliou – Thermal properties of the smallest EUV brightenings observed with SolO/HRI-EUV and SDO/AIA

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On May 2020, the high resolution UV imager EUI-HRI, onboard Solar Orbiter, made its first observation of the quiet solar corona at the highest resolution (200 km in the corona) and cadence (5 s) up to this day. This observation is of particular interest, because it falls within the context of small scale heating, potentially explaining the temperature of the solar corona in the order of 1 MK. During this 5 minutes sequence, 1467 small brightenings have been detected (Berghmans et al. , 2021). Their temperature distribution has been estimated to peak around 1.2 MK.

In order to analyze their thermal behavior in more details, we measure their time lags between the multichannel light curves of SDO/AIA. These time lags can be a consequence of heating or cooling processes of the plasma along the line of sight, and are a useful tool to constraint numerical modellings of heating.

We use couples between 6 EUV channels of AIA to cover a large range of coronal and transition region temperatures, while taking into account the effects of coronal red noise and background variations. We compare the pixel-by pixel distributions of the time lags and the maximum correlation values between the events and the rest of quiet Sun, resulting from the cross-correlation between the different couples of AIA sequences.

As a result, we measure the time lags of these brightenings to be mostly unresolved in time with the AIA cadence of 12 s. These short time lags may be consistent with either plasma at transition region temperatures, or the cooling of a short loop previously heated at coronal temperatures.

P13: L Alberto Canizares – Tracking Solar Radio Bursts using Bayesian Methods

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Solar eruptive activity results in the expulsion of plasma and acceleration of particles. These energetic particles interact with the local plasma environment resulting in the generation of intense radio bursts known as solar radio bursts. Type III radio bursts are a particular type of solar radio burst attributed to electrons travelling along open magnetic field lines. When an electron travels along a magnetic field line, it will produce radio waves at the local plasma frequency which can then be detected from Earth. However, the acceleration mechanisms that eject these particles away from the Sun are not fully understood and are still subject to investigation. Tracking of these particles is usually performed by means of triangulating type III radio bursts observed by different spacecraft located in different positions around the inner solar system. However standard methods of triangulation are found to have large uncertainties. In this project, we investigate the use of bayesian statistics to obtain a probabilistic positional map of a type III radio burst using data from spacecraft such as Solar Obiter, Parker Solar Probe, Wind and StereoA as well as the potential of using these triangulations to study scattering and turbulent effects in the solar corona. Furthermore, we will explore the future application of this research applied to the ESA funded SURROUND concept, a six spacecraft constellation of CubeSats that would monitor for space weather activity.

P14: Louise Harra – Intriguing coronal upflows at the edge of a sunspot - what causes it and can it become part of the solar wind?

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During the Solar Orbiter perihelion on March 7 2022, Solar Orbiter observed an active region (NOAA 12960) with EUI high resolution imagers (HRI) and the Hinode EUV Imaging Spectrometer. During the high cadence HRI observations, there was a persistent blue-shifted upflow area in the active region. Similar upflows are often seen at the edges of active regions in the plage areas, and can contribute to the slow solar wind. In the case of AR12960, the upflow region is located unusually close to the strong magnetic field of the sunspot umbra, dominantly in the penumbra region. We analyse both imaging and spectroscopy data, and carry out magnetic modelling to determine if it is possible that this upflow region can make its way into the slow solar wind. The 2 second cadence, high spatial resolution HRI data allow us to explore all the small scale features and dynamics within the upflow region including small loops and small scale transients 'dots'.

P15: Luca Sorriso-Valvo – Radial evolution of turbulence in the inner heliosphere: multi-spacecraft coordinated studies

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The radial evolution of turbulence in the inner heliosphere is studied using coordinated multi-point, multi-spacecraft observations of particles and fields at different distances from the sun. Alignment between Solar Orbiter and Parker Solar Probe are examined, as well as other spacecraft and different configurations. In addition to the standard estimators of spectral energy and intermittency, third-order moment scaling laws are used to determine the turbulent energy transfer rate. This enables us to study with precision the decay of turbulence in the expanding solar wind. This is finally modeled after considering the known radial expansion effects on the turbulent fluctuations. Comparison with numerical simulations of decaying magnetohydrodynamic turbulence are presented.

P16: Allan Sacha Brun – How does the Sun control the heliosphere? Coupling the solar dynamo and wind

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We know that the solar wind and the heliosphere are modulated by the 11 yr solar cycle. The cyclic activity of the Sun is directly connected to its internal turbulent dynamo. Hence in order to answer one of Solar Orbiter's key questions, i.e. "how the Sun controls its corona and the heliosphere", we must couple the internal cyclic solar dynamo to its extended magnetized atmosphere and wind. To achieve this challenging goal, we will present multi-D numerical simulations performed with the PLUTO code that self-consistently treat the non linear feedback loop between the dynamo and the wind and vice versa. We find as expected that the time varying dynamo magnetic field impacts significantly the solar wind, with some dynamo features propagating far into the heliosphere. More surprisingly, we also find that having boundary conditions controlled by the wind for the dynamo (and a feedback from the torodial field generated at the solar surface) also modifies the dynamo. Such coupling, favors a larger quadupolar field and larger north-south asymmetries than a more classical dynamo model with simpler potential field boundary conditions. We also find that the difference of time scales between the slow dynamo and the fast wind plays a key role in the variability found in the heliosphere. A slower cycle helps having smoother velocity and magnetic features.

P17: Daniel Verscharen – Electron-driven instabilities in the solar wind

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The electrons are an essential particle species in the solar wind. They often exhibit non-equilibrium features in their velocity distribution function. These include temperature anisotropies, tails (kurtosis), and reflectional asymmetries (skewness), which contribute a significant heat flux to the solar wind. If these non-equilibrium features are sufficiently strong, they drive kinetic micro-instabilities. We present a semi-graphical framework based on the equations of quasi-linear theory to describe electron-driven instabilities in the solar wind. We identify opportunities for future observations of electron-driven instabilities with Solar Orbiter and conclude our presentation with a list of open research topics in this area.

P18: Sudip Mandal – A highly dynamic small-scale jet in a polar coronal hole

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In this talk, I will present an observational study of the plasma dynamics at the base of a solar coronal jet, using high resolution extreme ultraviolet imaging data taken by the Extreme Ultraviolet Imager on board Solar Orbiter, and by the Atmospheric Imaging Assembly on board Solar Dynamics Observatory. We observed multiple plasma ejection events over a period of ~1 hour from a dome-like base that is ca. 4 Mm wide and is embedded in a polar coronal hole. Within the dome below the jet spire, multiple plasma blobs with sizes around 1–2 Mm propagate upwards to dome apex with speeds of the order of the sound speed (ca. 120 km s^{-1}). Upon reaching the apex, some of these blobs initiate flows with similar speeds towards the other footpoint of the dome. At the same time, high speed supersonic outflows (~230 km s^{-1}) are detected along the jet spire. These outflows as well as the intensity near the dome apex appear to be repetitive. Furthermore, during its evolution, the jet undergoes many complex morphological changes including transitions between the standard and blowout type eruption. These new observational results highlight the underlying complexity of the reconnection process that powers these jets and also provide insights into the plasma response when subjected to rapid energy injection.

P19: Saqri, J. – Energy and impulsive CME dynamics in an eruptive C7 flare

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On April 17th, 2021, the Spectrometer Telescope for Imaging X-rays (STIX) onboard the Solar Orbiter spacecraft observed a flare that was partially occulted from Earth view. The flare was estimated to be of GOES class C7 and shows several episodes of non-thermal hard X-ray bursts over a total duration of about an hour. This event was also associated with a fast CME and is particularly interesting due to spacecraft positions on April 17th. For Solar Orbiter and STEREO-A, the flare occurred on disc, enabling us to study the response of the lower solar atmosphere to the flare particle acceleration and energy deposition using STIX X-ray imaging, spectral fitting and EUV images from STEREO EUVI. For earth-orbiting spacecraft like SDO which were separated by 98 degrees from Solar Orbiter, the flare occurred just behind the eastern limb, allowing us to study the flare related changes in the corona from a side on view and to put them into context of the STIX and STEREO on disc observations.

We find several instances of plasma motions such as detaching plasmoids, flare-related reconnection outflows and super arcade downflows observed by SDO AIA. Some of these plasma flows occur simultaneously with individual HXR bursts observed by STIX. The most distinct instance is the ejection of a hot plasmoid at the beginning of the impulsive flare phase where the acceleration coincides with a peak in the HXR lightcurve. We analyze the dynamics and thermal properties of the flare-related plasma flows and the flaring arcade as well as the energy releases and particle acceleration as diagnosed by STIX. Combining different vantage points and instruments allows us to perform a detailed study of the flare and the related eruption over a wide range of atmospheric heights.

P20: Nawin Ngampoopun – The evolution of an erupting filament and the South Polar Coronal Hole boundary during Solar Orbiter's First Perihelion

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In this work, we report a southern hemisphere filament eruption that occurred on 2022 March 18, during the first perihelion of Solar Orbiter. The filament erupted as a coronal mass ejection (CME), producing transient dimmings at the footpoints of the erupting structure. The eruption, and its associated expanding magnetic field, appear to have modified the structure of the adjacent southern polar coronal hole, producing a merged coronal hole/CME dimming region. This work aims to understand the physical processes triggered by the filament eruption, which led to the merger of the CME dimming region and coronal hole. These processes could be related to how magnetic reconnection driven by a CME can open magnetic field lines to interplanetary space and impact the solar wind. We use remote sensing data from multiple co-observing spacecraft to study the southern polar coronal hole and CME dimming merger. In particular, the evolution of the merging process is examined using Extreme-UltraViolet (EUV) images obtained from the Extreme Ultraviolet Imager instrument onboard Solar Orbiter and Solar Dynamic Observatory spacecraft. The plasma evolution is then quantified using EUV spectroscopic data obtained from the EUV Imaging Spectrometer onboard Hinode. This work aims to advance our understanding of magnetic and plasma evolution at coronal hole boundaries, which could have important impacts on the origin of the solar wind.

P21: Antonio Vecchio – Refinement of the Solar Orbiter/RPW antenna calibration in the radio domain and its application to type III burst observations

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In order to allow for a comparison with the measurements from other antenna systems and to model properly the observed radio sources, the voltage power spectral density measured by the Radio and Plasma waves receiver (RPW) on board Solar Orbiter needs to be calibrated, namely converted into physical quantities depending on the intrinsic properties of the radiation itself (e.g., incoming flux density). To this purpose, instrumental parameters, such as the antennas' effective lengths and capacitances and the noise level of the receivers, need to be measured in flight in the real physical conditions of operation that (due to the effect of the spacecraft body and the low density environment) are not reproducible on the ground. A typical approach to performing this conversion is to observe a known source of electromagnetic radiation and relate the RPW measurement to the flux of the source.

In this contribution we present a refinement of the preliminary RPW antenna calibration by comparing three different kind of calibration sources and in-flight measurements from the Thermal Noise Receiver (TNR) and the High Frequency Receiver (HFR) of RPW:

1. The type III solar radio bursts flux density, as measured by other spacecraft, for several events.
2. The isotropic non-thermal Galactic radio background.
3. Several radio pulses in the range 2-10 MHz emitted by the Ionospheric Research Instrument of the High-frequency Active Auroral Research Program (HAARP) based in Alaska and recorded by RPW during the EGAM of 26-27 November 2021.

It will be shown how the detailed comparison between TNR-HFR measurements and the expected flux from the different sources above allowed to obtain the effective length of the RPW antennas and the reference system noise of TNR-HFR in space, where the antennas and pre-amplifiers are embedded in the solar wind plasma.

P22: Antonio Vecchio – Refinement of the Solar Orbiter/RPW antenna calibration in the radio domain and its application to type III burst observations

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P23: Stefano Livi – Preferential Acceleration of Suprathermal Particles at Shocks

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On October/November 2021 the Heavy Ion Sensor onboard Solar Orbiter observed data connected to three interplanetary shock events: Oct 30, Nov 3 and Nov 27. During all three events, the flux of suprathermal particles, defined as those having an energy larger than twice the energy of the solar wind component, showed remarkable intensification. We discuss those changes and specifically how particles of different mass/charge and energy/charge distribution before the shock are affected differently by the interaction with the shock front itself. From these three examples, it appears that intensifications are stronger for species already having a seed population in the suprathermal regime.

P24: Alexander Warmuth – Energy partition in solar flares: first results from new observations and new models

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Solar eruptive events are characterized by a complex interplay of energy release, transport, and conversion processes. Over the past two decades, the energetics of both the thermal plasma and the accelerated non-thermal electrons have been studied extensively using RHESSI data and the cold thick-target model. Here, we report on first results using two novel approaches: (1) HXR spectroscopy using STIX data, which have the advantage of a very stable background, and (2) applying the warm-target model, which can provide upper estimates of the non-thermal electron energetics.

P25: Simon Opie – Using high resolution observations from Solar Orbiter to investigate the conditions for kinetic scale instabilities to act in the solar wind

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The solar wind is inherently turbulent and characterised by kinetic instabilities which transfer energy to small-scale fluctuations. These instabilities are driven by various sources of free energy (e.g. particle beams, differential flows, heat fluxes, temperature anisotropies) and make a significant contribution to the fluctuation spectrum at kinetic scales, where energy dissipation occurs.

We consider instabilities driven by proton temperature anisotropy in the solar wind by using statistical methods to analyse Solar Orbiter data and characterise the conditions required for wave-particle interactions to occur. We show how conditions that are necessary for instabilities to act in a turbulent plasma relate to the assumptions that underpin theoretical analyses at kinetic scales. We quantify the temporal and spatial scales of energy transfer processes with particular reference to scaling law behaviours in the turbulent solar wind.

P26: Roberto Bruno – On the radial evolution of plasma kinetic features based on SWA-PAS observations

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During the first quarter of 2022 Solar Orbiter experienced a large radial excursion between the Earth's orbit and its first close approach to the Sun at 0.32 AU. This orbital feature offers the possibility to study the radial evolution of the kinetics characterizing the proton and alpha particle velocity distribution functions.

Within the framework of this study we adopted a novel numerical tool based on machine learning technique able to separate proton core, proton beam and alpha particle populations directly form the 3D velocity distribution functions recorder by SWA-PAS.

In this presentation we focus on Alfvénic intervals observed by SWA-PAS at different heliocentric distances and will report on the evolution of kinetic parameters relative to these particle populations.

P27: Alexander James – Evolution of the critical torus instability height and CME likelihood in solar active regions

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Aims: Working towards improved space weather predictions, we aim to quantify how the critical height at which the torus instability drives coronal mass ejections (CMEs) varies over time in a sample of solar active regions.

Methods: We model the coronal magnetic fields of 42 active regions and quantify the critical height at their central polarity inversion lines throughout their observed lifetimes. We then compare these heights to the changing magnetic flux at the photospheric boundary and identify CMEs in these regions.

Results: We find higher rates of CMEs per unit time during phases when magnetic flux is increasing rather than decreasing, and when the critical height is rising rather than falling. Furthermore, we support and extend the results of previous studies by demonstrating that the critical height in active regions is generally equal to half of the separation of their magnetic polarities through time.

P28: Jana Safrankova – Power spectral density of magnetic field fluctuations from Sun to Earth

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The paper analyzes power spectra of magnetic field fluctuations that are computed in the frequency range around the break between inertial and kinetic scales. We use Solar Orbiter measurements, complement them with observations made during first nine Parker Solar Probe encounters and compare them with observations of the spacecraft moving closer to 1 AU. We have found that the relative level of compressive fluctuations increases until 0.25 AU and remains constant till 1 AU whereas a relative level of perpendicular fluctuations does not change with the distance from the Sun. A preliminary analysis of magnetic field fluctuations at MHD range has shown that the slope of the power spectral density starts from about -3/2 close to the Sun and gradually changes to -5/3 typically observed at 1 AU. On the other hand, the slope in the kinetic range exhibit a significant evolution till 0.25 AU where it reach values known from 1 AU. We can conclude that the evolution of solar wind turbulence is controlled by different process(es) close to the Sun and at 1 AU and that, in spite of expectations, the critical distance for turbulence evolution is as large as 0.25 AU. We also discuss the role of important physical parameters (e.g., ion beta, temperature anisotropy, collisional age, magnetic field fluctuation amplitude) determining the properties of the turbulent cascade in different heliospheric locations.

P29: Melissa Pesce-Rollins – The coupling of an EUV coronal wave and ion acceleration in a Fermi-LAT behind-the-limb solar flare

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We present the Fermi -LAT observations of the behind-the-limb (BTL) flare of July 17, 2021 and the joint detection of this flare by STIX onboard Solar Orbiter. The separation between Earth and the Solar Orbiter was 99.2 degrees at 05:00 UT, allowing STIX to have a front view of the flare. The location of the flare was S20E140 making this the most distant behind-the-limb flare ever detected in >100 MeV gamma rays. The LAT detection lasted for ~16 minutes, the peak flux was 3.6 ± 0.8 (10^{-5}) ph cm^{-2} s^{-1} with a significance >15 sigma. A coronal wave was observed from both STEREO-A and SDO in extreme ultraviolet (EUV) with an onset on the visible disk in coincidence with the LAT onset. A complex type II radio burst was observed by GLOSS also in coincidence with the onset of the LAT emission indicating the presence of a shock wave. We discuss the relation between the time derivative of the EUV wave intensity profile at 193 Å as observed by STEREO-A and the LAT flux to show that the appearance of the coronal wave at the visible disk and the acceleration of protons as traced by the observed >100 MeV gamma-ray emission are coupled. We also report how this coupling is present in the data from 3 other BTL flares detected by Fermi -LAT suggesting that the protons driving the gamma-ray emission of BTL solar flares and the coronal wave share a common origin.

P30: Teodora Mihailescu – What determines active region coronal plasma composition

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The chemical composition of the solar corona is different from that of the solar photosphere, with the strongest variation being observed in active regions (ARs). Using data from the Extreme Ultraviolet Imaging Spectrometer on Hinode, we present a survey of coronal elemental composition as expressed in the first ionization potential (FIP) bias in 28 ARs of different ages and magnetic flux content, which are at different stages in their evolution. We find no correlation between the FIP bias of an AR and its total unsigned magnetic flux or age. However, there is a weak dependence of FIP bias on the evolutionary stage, decreasing from 1.9 to 2.2 in ARs with spots to 1.5–1.6 in ARs that are at more advanced stages of the decay phase. FIP bias shows an increasing trend with average magnetic flux density up to 200 G, but this trend does not continue at higher values. The FIP bias distribution within ARs has a spread between 0.4 and 1. The largest spread is observed in very dispersed ARs. We attribute this to a range of physical processes taking place in these ARs, including processes associated with filament channel formation. These findings indicate that, while some general trends can be observed, the processes influencing the composition of an AR are complex and specific to its evolution, magnetic configuration, or environment. The spread of FIP bias values in ARs shows a broad match with that previously observed in situ in the slow solar wind.

P31: A. Bemporad – Analysis of the first coronagraphic multi-band observations of a sungrazing comet

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Between December 24-25, 2021 a sungrazing comet (SOHO-4341) approached the Sun, being observed by "classical" visible-light (VL) coronagraphs on-board the SOHO and STEREO missions, and also by the innovative Metis coronagraph on board the ESA-NASA Solar Orbiter mission in the VL and UV (H I Lyman-α) bands. Observations by different spacecraft have been combined to derive the 3D trajectory of the comet, providing useful information for the interpretation of the Metis data. By using the comet positions tracked with VL images having a 4 times larger spatial resolution, the UV images (with a time cadence 5 times better than VL) have been coaligned, to maximize the signal-to-noise ratio in the UV.

The resulting UV tail shape has been analyzed to derive useful information on the solar corona crossed by the comet. In particular, the local electron density was measured from the observed exponential decay of the UV Lyman-α intensity along the tail, while the solar wind speed was measured from the Lyman-α tail inclination with respect to the cometary orbital path deprojected in 3D. Moreover, the proton kinetic temperature Tk was also obtained by the aperture angle of the UV tail. All these parameters were derived independently from the UV radiometric calibration, at significant distances from the Sun (14 solar radii) and also above the ecliptic plane (approximately 40°), in locations that will never be measured in situ by the on-going NASA Parker Solar Probe mission (limited around the ecliptic plane) or by the instruments on-board the ESA-NASA Solar Orbiter mission (whose inclination will reach a maximum value of 33° from the ecliptic plane). Hence, sungrazing comets are unique "local probes" for the ambient coronal plasma, providing measurements that are not affected by the line-of-sight integration effects as those provided by remote sensing instruments observing the solar corona.

P32: Daria Sorokina – MHD modeling of coronal streamers and their oscillations

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A numerical model is needed for streamer wave phenomena. Studying the waves is essential for coronal seismology, which was made possible after the recent construction of an observational database, and for supporting the developing theory. In the present work, we present a simple model of a helmet streamer slightly shifted from the solar equator and observe the oscillation of the streamer after introducing a perturbation of the initial velocity. The results are qualitatively compared with the STEREO observations. To perform the 2.5D simulation of a streamer event, we use the MHD module of the MPI-AMRVAC code. This study contributes to understanding the physical mechanism underlying streamer waves and the plasma properties of the coronal streamers.

P33: Jinge Zhang – LOFAR Radio Diagnostics of Large Solar Corona Magnetic Loops and Near-Relativistic Electrons

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Electron beams propagating along closed coronal loops can produce radio U bursts, whilst beam propagation along open flux tubes can produce type III radio bursts. Imaging U bursts combined with spectroscopic analysis provides opportunities to study electron beams transport and the physical properties of coronal magnetic loops. However, U bursts are less commonly observed than type III and type J bursts because electron beams tend to stop producing radio emission in the descending leg of the magnetic loop. Previous radio imaging observation studies have considered why electrons do not produce so much radio emission in the descending leg, but only a few frequency bands were imaged due to limitations in historic radio observatories. The LOw-Frequency-ARray (LOFAR) provides significantly improved frequency coverage for radio imaging, combined with sub-second time resolution. On the 5th of June 2020, LOFAR observed a bright U burst between 20 to 80 MHz, which has an extremely clear descending leg structure. The Solar Orbiter Radio and Plasma Waves (RPW) instrument simultaneously observed an interplanetary type III radio burst between 0.1 to 10 MHz, which has a strong connection to the U burst. Using LOFAR, we image the U burst from the ascending to descending leg to study the processes of electron beams propagating though both parts of the magnetic loop. We derive the properties of the background plasma within the large (> 1 solar radii) coronal loop, and the associated loop geometry. We also compare the properties of the U burst with the interplanetary type III burst observed by Solar Orbiter to see whether there is any inherent differences between the electron beam that is confined to the solar corona and the one that escapes into the heliosphere.

P34: Harry Greatorex – The Impact of Nonthermal Electrons on Lyman-alpha Emission during Solar Flares

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The chromospheric Lyman-alpha (Lyα) line of neutral hydrogen at 121.6 nm is the most intense emission line in the solar spectrum and is believed to constitute a considerable portion of the total radiated energy in solar flares. Interest in the study of Lyα has increased in recent years due to the greater availability of observations at this wavelength on flare timescales. Here I present a multi-wavelength study of three M3 flares that occurred near disk centre, and were simultaneously observed by RHESSI, GOES/EUVS-E, and SDO/EVE. Despite having identical X-ray magnitudes these flares show significantly different Lyα responses. The Lyα enhancements above quiescent background for these flares were 1.5%, 3%, and 6%. However, the predicted Lyα enhancements from the Flare Irradiance Spectral Model (FISM2) were consistently <2%. Variations in Lyα emission in these flares may be due to differing properties of non-thermal electrons incident on the chromosphere. To diagnose the properties of these electrons, spectral fitting techniques were applied to Hard X-Ray data from RHESSI. Comparing the energy in non-thermal electrons to the radiative losses in Lyα, it was found that the percentage of energy radiated in the Lyα line ranges from 8-32%. Comparatively, the radiative losses in He II (30.4 nm) were found to range from 3-7%. These results may have significant implications for space weather studies and atmospheric modelling, and will influence the interpretation of flare-related Lyα observations in Solar Cycle 25.

P35: Ryan Milligan – Lyman-alpha Variability During Solar Flares

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The chromospheric hydrogen Lyman-alpha line at 1216Å is the brightest emission line in the solar spectrum, and yet studies of solar flares at this wavelength have been scarce in the recent literature. Changes in the Sun's Lyman-α output can drive changes in the dynamics and composition of planetary atmospheres, and Lyman-α is also a significant radiator of solar flare energy providing an important diagnostic of energy release and transport processes. Milligan et al. (2020) published a statistical study of ~500 M- and X-class flares using GOES/EUVS data, showing that although the Lyman-α irradiance increases by only a few percent during large events, it can radiate up to 100 times more energy than the corresponding X-rays. Flares that occurred closer to the solar limb, however, were found to exhibit a smaller Lyman-α enhancement relative to those on the disk due to opacity and/or foreshortening effects. It was also shown that acoustic oscillations in the chromosphere can be detected through Lyman-α flare observations, and that impulsive Lyman-α emission, not X-rays, can induce currents in the E-layer of Earth's ionosphere. A follow-up study included B- and C-class flares (Milligan 2021), which although not readily observable in disk-integrated measurements, can be investigated using a superposed epoch analysis. Despite increases of <1% above the solar background, a clear centre-to-limb variation was found in agreement with larger events. These findings should serve as a baseline for the advent of new Lyman-alpha flare observations and advanced numerical simulations that will become available during Solar Cycle 25.

P36: Nikolina Milanovic – Thermal structuring and evolution of coronal bright points

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Coronal bright points (CBPs) are prominent and widespread features of the quiet solar corona and coronal holes. They are best observed in the extreme-ultraviolet (EUV) and X-rays, and have lifetimes of up to several hours. They appear as systems of small loops of sizes of about 10-20 Mm, connected to bipolar magnetic field concentrations in the photosphere. Investigating their thermal structuring will provide important constraints on their heating mechanisms. To this end, we report on the thermal characteristics of CBPs using early observations from the EUV spectrometer SPICE onboard Solar Orbiter. One unique feature of SPICE is its simultaneous coverage of a broad temperature range from coronal plasma to the low transition region and down to 0.01 MK. Overall, the differential emission measure (DEM) in the CBPs increases at all temperatures when compared to the quiet Sun. In particular, the slope of the DEM below ca. log T[K]=5.2 is the same in the quiet Sun and CBPs. However, above this temperature, the increase of the DEM towards the corona is shallower, with only a small increase at temperatures just below 1 MK. From this we conclude that plasma around 1 MK gets heated to higher temperatures and is not (fully) replenished by transition region material heated to 1 MK. To investigate how these changes of the DEM can be understood in terms of temporal evolution, we use data from the Extreme Ultraviolet Imager (EUI) onboard Solar Orbiter. This allows us to follow the fast evolution of substructures in CBPs at high spatial resolution and to study how the coronal emission responds to heating events. With this we aim to understand how the dynamic substructure of the CBPs governs their systematic thermal structure as revealed by SPICE.

P37: Catia Grimani – Cosmic-ray and solar energetic particle monitoring with the Solar Orbiter Metis coronagraph

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Cosmic rays of galactic and solar origin with energies larger than tens of MeV penetrate spacecraft and instrument materials of space missions. The Solar Orbiter Metis coronagraph is meant at imaging the solar corona in both visible light (VL) and ultraviolet (UV). A detector onboard algorithm allows us to separate VL image pixels fired by cosmic rays and by photons.

We complete here a previous work by studying the role of rare galactic cosmic rays and of solar energetic particles in affecting the Metis VL detector performance. Solar energetic particle events of different intensities are considered. Simulations of the impact of charged particles on the UV detector are also carried out for the first time. Finally, we report about the charging process of not grounded parts caused by cosmic rays and by solar energetic particles of the UV instrument.

P38: Rui Pinto – Forward modelling of solar flare emissions in the Solar Orbiter era

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Solar flares consist of episodes of intense EUV and X-ray emission that follow from quick releases of energy stored in coronal structures with complex magnetic fields. Twisted magnetic flux-ropes are likely to play a central role in the triggering and evolution of solar flares, as they are susceptible to develop instabilities leading to quick energy releases in the form of strong coronal plasma heating and of particle acceleration. The interdependence between the large scale topology of the magnetic field and its small scale dynamics determines to a great extent the outcome of such processes (occurrence conditions, amplitude, plasma and particle ejection). Detailed and energetically consistent numerical simulations are thus required to determine the physical links between the magnetic field, the bulk plasma thermodynamics, the charged particle motions, and the corresponding observable electromagnetic signatures.

We will present recent simulations focusing on impulsive plasma heating and particle acceleration in modelled solar flares triggered in twisted coronal loops. We use a hybrid approach based on 3D MHD, test-particle and Particle-In-Cell (PIC) techniques. We discuss the outcomes of the simulations in terms of the morphological and spectral properties of the forward-modelled emission in the context of the Solar Orbiter mission, and of the STIX instrument.

P39: Yamini K. Rao – Path Length Estimations in the Transition Region using IRIS observations

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The transfer of mass and energy from the chromosphere to the corona takes place through the transition region, which is a complex, highly structured, dynamic region. The center-to-limb variation of non-thermal velocities in the quiet Sun (QS) has been observed in our previous study using high-resolution spectral observations from the Interface Region Imaging Spectrograph (Rao et al., 2022). The filling factor (amount of TR plasma long the line of sight has been found to be very small, indicating a highly structured nature. Using HRTS data, Dere et al. (1987) reported a filling factor ranging from 10^{-5} to 10^{-2} using OIV and a C IV line. The corresponding path lengths were found to be in the range of 0.1–10 km. In more recent work, we have used density-sensitive lines from O IV and S IV to estimate the electron densities and temperature using high-resolution spectral observations binned to 2″ in spatial resolution from the Interface Region Imaging Spectrograph (IRIS). We also use new atomic models (Dufresene et al., 2021) for the quiet Sun, which include density effects, photo-ionization, and charge transfer to estimate the filling factors and path lengths. Our study of how data from such models can affect the analysis will be useful for interpretation of observations from Solar Orbiter SPICE spectrometer.

P40: Ross Pallister – Parameter study of low-energy heliospheric electron transport from the solar corona

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Non-thermal acceleration of particles in the solar corona is evident from both remote and in-situ observations of high-energy emission, however the plasma properties of the volumes in which this acceleration take place are not fully understood. In addition, it has not been established whether particles that produce remote and in-situ signatures of this acceleration share a common source region, and what the properties of this region would have to be.

We present results of the first stage of this study: we simulate the 1D transport of thermal electrons from a coronal region out to 1 AU subject to collisional and non-collisional scattering effects. This coronal region has fixed properties (region size, electron plasma temperature and density) which are varied between simulations to examine how the electron energy and pitch-angle distributions differ along the heliosphere according to different configurations of these properties.

Later stages of this study will also be discussed: the inclusion of an acceleration profile in the coronal region, additional scattering and diffusion effects in the heliosphere, and the modelling of chromospheric incident particles to produce simulated remote observations. The ultimate aim of this study will be to compare these simulated observations with actual data (from instruments mounted on spacecraft such as Solar Orbiter) in order to constrain the plasma properties of acceleration regions in the corona and transport effects in the heliosphere.

P41: Paolo Massa – Hard X-ray observations of solar flares with STIX: morphologies and their interpretation

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The Spectrometer/Telescope for Imaging X-rays (STIX) observes hard X-ray emissions of solar flares by means of Moiré patterns that provides Fourier components of the incoming radiation flux. This talk focuses on several X-ray configurations observed by STIX and characterized by complex morphologies. The reconstructed images are validated by comparison with EUV maps provided by SDO/AIA and EUI on-board Solar Orbiter. Further, we illustrate the temporal and spectral evolutions of such morphologies and provide their interpretation within the framework of thin- and thick-target models for high-energy emission in the solar chromosphere and corona.

P42: Shilpi Bhunia – Imaging-spectroscopy of radio signature of shock with the Murchison Widefield Array.

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Often solar energetic events such as coronal mass ejections (CMEs) drive shocks while propagating away from the sun. These shocks then generate plasma emission which in turn produces a type II radio burst, a slow drifting radio feature. Often they exhibit various kinds of spectral and temporal fine structures. Also, both fundamental and harmonic bands of type II bursts are split into two sub-bands. Studying these various structures gives insight into the shock particle acceleration and coronal turbulence encountered by shocks. Here we present results from imaging analysis of type II radio burst band-splitting and fine structures observed by the Murchison Widefield Array (MWA) on 2014-Sep-28. The MWA provides high-sensitivity imaging spectroscopy in the range of 80-300 MHz with a time resolution of 0.5 s and a frequency resolution of 40 kHz. Our analysis provides rare evidence that band-splitting is caused by emissions from multiple parts of the shock. We also examine the small-scale motion of type II fine structure radio sources in MWA images. We suggest that this small-scale motion may arise due to propagation effects from coronal turbulence. The study of the systematic and small-scale motion of fine structures may therefore provide a measure of turbulence in different regions of the shock and corona. In the future, this study can be further continued by combining the remote sensing observations of shock and the coronal turbulence from ground-based radio instruments with in-situ observations from Solar Orbiter. Such an observational analysis would be a first in the field of solar and heliospheric physics.

P43: Thomas Chust – Solar Orbiter's RPW Low Frequency Receiver (LFR) : In-flight performance and observations of whistler mode waves

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The Radio and Plasma Waves (RPW) instrument is one of the four in situ instruments of the ESA/NASA Solar Orbiter mission. The Low Frequency Receiver (LFR) is one of its subsystems, designed to characterize the low frequency electric (quasi-DC – 10 kHz) and magnetic (~1 Hz–10 kHz) fields that develop, propagate, interact, and dissipate in the solar wind plasma. Combined with observations of the particles and the DC magnetic field, LFR measurements will help to improve the understanding of the heating and acceleration processes at work during solar wind expansion.

In this presentation, we want to show the ability of LFR to observe and analyze a variety of low frequency plasma waves, taking advantage of whistler mode wave observations. This concerns in particular its ability to measure the wave normal vector, the phase velocity, and the radial Poynting flux to determine the propagation characteristics of the waves

Several case studies of whistler mode waves are presented, using all possible LFR onboard digital processing products, waveforms, spectral matrices, and basic wave parameters. Here, the waves on the whistler mode are very well identified and characterized, as well as their frequency shift by Doppler effect, both by the ground analysis of the waveforms and by the spectral analysis on board. These first observations of whistler mode waves show a good overall consistency of the RPW LFR data, which allows us to hope that new scientific results on these waves, as well as on other plasma waves, will soon be obtained by Solar Orbiter in the solar wind.

P44: Amanda Romero Avila – Sunspots and pores height measurements using stereoscopic observations.

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A compound method for a stereoscopic analysis of the height variations in the solar photosphere is presented. This method allows to estimate relevant quantities (i.e. the Wilson depression) and to study structures in the solar photosphere and within sunspots. We will demonstrate the feasibility of the method using simulated Stokes I continuum observations derived from a radiative transfer model using the plasma properties of a MHD simulation of the solar surface. The large scale variations in our method are estimated by shifting and correlating two signals of the same region as observed from two different view directions. This result is then introduced as an initial height estimate in a least squares optimization algorithm in order to reproduce smaller scale structures. This method has been developed to be applied to the high resolution images of the PHI instrument on board Solar Orbiter or similar instruments on other Sun-observing spacecraft. A rectification of the images is necessary before the application of this method, which will allow to perform direct stereoscopic studies of solar surface observations in different wavelengths of the solar spectrum. Preliminary results, advantages and limitations, applications and particular considerations for PHI data, as well for data from other spacecrafts/telescopes will be discussed.

P45: Michele Piana – From RHESSI to STIX: the importance of multi-modal observation in hard X-ray imaging

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STIX is the actual RHESSI epigone. In fact, both instruments aim at understanding how energy release occurs during solar flares and for both ones the native measurements are Fourier components of the incoming flux named visibilities. However, the main breakthrough associated to the STIX mission is the fact that STIX measurements can be naturally integrated with data provided by other Solar Orbiter observations of the same event. This talk will first briefly discuss the main different potentialities of RHESSI and STIX when taken as stand-alone telescopes. Then, we will illustrate a first example of how observations of the same solar event provided on March 25 2022 by four remote sensing instruments on-board Solar Orbiter, can be integrated to unveil and track the multi-scale and multi-wavelength processes characterizing solar eruptions.

P46: Helen Rose Middleton – The Solar Orbiter Archive (SOAR)

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The Solar Orbiter ARchive (SOAR; http://soar.esac.esa.int) provides access to all publicly available data from the Solar Orbiter mission provided by the instrument teams so far. Access is via web interface and/or command line, and direct access is also available through Python packages such as SunPy.

The web interface allows simple searches by instrument and data level plus more specific filename searches for product types ("descriptors"), for example. Metadata is easily viewable in the Results display, and provides postcards of EUI data, for easier browsing. SAMP (Simple Application Messaging Protocol) enables files to be sent directly from the archive web interface to other applications (e.g., Autoplot, JHelioviewer, TOPCAT or Aladin), for viewing and manipulation, and JHelioviewer connects to a SOAR JPIP server to display EUI L3 JPEG2000 images. Instrument teams' private data is also stored and available with layers of privileged access.

For command line/scriptable access, the Table Access Protocol (TAP) enables powerful searches and direct access to data and metadata, and full help pages are provided with extensive examples.

This poster will demonstrate all these aspects and features of the Solar Orbiter archive that enable community access to the most important part of any mission – the data!

P47: Anik De Groof – Solar Orbiter's coordinated science operations: Planning 6-monthly encounters with a star, seen from truly unique viewpoints

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After a Cruise Phase of 21 months, Solar Orbiter entered its first scientific orbit end November 2021 after a Gravity Assist Manoeuvre (GAM) by the Earth. The spacecraft entered a highly elliptical orbit that brought it to its first close perihelion in March, at 0.32AU from the Sun, and will bring it even closer in autumn 2022. Future GAMs by Venus will tilt the orbit out of the ecliptic plane, which will allow the first ever views on both solar poles.

Solar Orbiter's main goal is to study the connection between the Sun's activity and its effects in the heliosphere, incl. at Earth. Therefore, the mission goals hinge on coordinated observations of the full payload, six remote-sensing telescopes observing the dynamic Sun and 4 in-situ instruments measuring the solar wind surrounding the spacecraft.

Instrument observations cannot be planned in isolation but are rather grouped in so-called Solar Orbiter Observing Programmes (SOOPs) tailored to the science questions we want to address during a particular opportunity. Also, Solar Orbiter's unique orbit around the Sun implies mission resources like downlink speed to greatly vary throughout the operations phase. This makes that science planning needs careful coordination and resource optimisation, in order to fully exploit the capabilities of this exciting mission.

In this poster, we present the Mission's science operations concept and the observations planned for the first year of Nominal Mission Phase, i.e., the first two orbits. By the time of the workshop, the spacecraft will have returned the data of its first close encounter and will be speeding towards the second and closest one in October 2022.

P48: Emiliya Yordanova – Extended spatial heating in the solar wind: case studies

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Numerical simulations and some recent observations have shown that local heating in the dispersion/dissipation range of turbulence is associated with coherent structures near ion or at sub-ion scales. In a very recent study (Yordanova et al. 2021) we found intermittent meso-scale spatial blobs of enhanced temperature corresponding to size of tens of thousands of ion inertial lengths in the turbulent sheath region of a CME that were associated with groups of current sheets and vortical flows, and correlations between them that are over a threshold. The method has been based on the Partial Variance of Increments (PVI) calculated from the magnetic field and plasma velocity and used as single point proxies for the estimation of the current and the vorticity. Then coarse-grain correlations of the conditioned proxies have been related to coherent structures and temperature enhancements. In this work, we apply the same method and investigate the occurrence of such correlations in different plasma conditions by comparing quiet solar wind with disturbed solar wind associated with transients, such as CMEs and SIRs observed by the Solar Orbiter spacecraft at different heliodistances. The preliminary results indicate that turbulence generated local heating can be associated with rather significant heating of plasma in larger volumes.

P49: David Williams – Solar Orbiter's Mission Plan: How we capitalise on rare and important opportunities to see our star

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Solar Orbiter has, by nature, a long mission. The need to progressively incline its trajectory to see the solar poles takes time and means that the highly eccentric orbit resonates not with Earth but with Venus: geometric opportunities with the Earth do not repeat identically.

During the 10 years of its Cruise, Nominal and Extended phases, the mission will sample phenomena in the solar wind and on the Sun across a large parameter space: different parts of the solar cycle; a range of distances, latitudes, and inclinations; and a variety of longitudinal and latitudinal separations with both Earth (+Hinode, IRIS, SDO, Cluster) and other deep-space missions – STEREO, BepiColombo and its closest cousin, Parker Solar Probe

There are therefore a host of rare, often unique opportunities to study particular science topics with Solar Orbiter. Here, we present the mission's trajectory, and take the reader through the steps that the Science Working Team has taken to get from the mission's objectives to working out a strategy and a living Science Activity Plan that tries to make sure we answer all the science questions that Solar Orbiter can, and as best it can. In a companion poster, we show this approach distilled into the concrete example of the first year of science observations.

P50: A. Settino – Solar Orbiter observation of Kelvin-Helmholtz structures in different phases

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Kelvin-Helmholtz (KH) instability is a velocity shear driven phenomenon which can develop in plasmas when a threshold condition is satisfied. Typically, a magnetic field component in the plane of the shear tends to stabilize the KH. Thus, a nonalignment of magnetic and velocity field is necessary for its development. Velocity discontinuities with such kind of feature are very common in the solar wind, making this environment suitable for KH generation. Recently, KH instability has been detected in situ, for the first time, in the slow solar wind at about 0.7 A.U. by the high resolved Solar Orbiter measurements (1). However, KH vortices are not easily detected in situ and their identification remains still a challenging problem.

Very recently, different kinetic quantities have been suggested for the identification of KH vortices and successfully used on MMS measurements at the Earth's magnetopause [2,3]. We observe the presence of such features also in the first in situ measurement of KH structures in the solar wind.

Thanks to such kinetic quantities we have identified the crossing by Solar Orbiter of another train of KH vortices about an hour before the observation reported in Ref. (1)

Our analyses suggest that this second train of vortices is in a different evolutionary phase of the instability with respect to the first observation (4).

The identification of more KH structures in the solar wind can give an important contribution to the long standing problem of its anomalous heating. Indeed, in the near Earth's environment the nonlinear KH instability has been observed to importantly contribute to the local heating of plasma.

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(2) Settino, A., et al. (2020). ApJ, 901(1), 17.
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(4) Settino, et al. in prep.

P51: Philippe Louarn – On the structure of proton beams in the solar wind and their model distribution functions.

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A secondary proton population (ion beam) is often observed in the solar wind. This non-thermal feature is characterized by a velocity shift of the order of the Alfven velocity with respect to the core Maxwellian proton population. Its existence results most certainly from non-linear wave-particle interactions, including Alfvénic turbulence. Using measurements of the Proton-Alpha Sensor (PAS), part of the Solar Wind Analyzer (SWA) of Solar Orbiter, it is shown that the beams are not 'simply' shifted gaussian distributions. They are asymmetric, with a more populated high-energy side ('heavy tail') compared to the gaussian distribution. Among classical statistical distributions, it appears that the 'Inverse Gaussian Distribution' (IGD) provides excellent fits. Then, remarkably good models of the whole proton distribution are obtained by superposing a gaussian (for the core) and an IGD (for the beam). A vast literature describes the statistical properties of IGD, with applications in physical, chemical, biological and financial contexts. The finding of so good fits with IGD is an indication of the richness of the underlying formation processes of the beam (Levy flights, intermittency, anomalous diffusion, fractional Fokker-Planck equation…) and may open new directions for their interpretation.

P52: Nived Vilangot Nhalil – Detection of spicules termed Rapid Blue-shifted Excursions as seen in the chromosphere via H-alpha and the transition region via Si iv 1394 line emission

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We show signatures of spicules termed Rapid Blue-shifted Excursions (RBEs) in the Si IV 1394 Å emission line using a semi-automated detection approach. We use the Hα filtergrams obtained by the CRISP imaging spectropolarimeter and co-aligned SJI 1400Å channel to investigate the Spatio-temporal signature of the RBEs in the transition region. The detection of RBEs is carried out using an oriented coronal loop tracing algorithm on Hα Dopplergrams at +35 km/s. We find that the number of detected features is significantly impacted by the time-varying contrast values of the detection images, which are caused by the changes in the atmospheric seeing conditions. We detect 407 events with lifetime greater than 32 sec. This number is further reduced to 168 RBEs based on the Hα profile and the proximity of RBEs to the large-scale flow. Of these 168 RBEs, 89 of them display a clear Spatio-temporal signature in the SJI 1400Å channel, indicating that a total of ~53% are observed to have co-spatial signatures between the chromosphere and the transition region. The 1394Å spectral analysis reveals that there is a co-spatial and co-temporal enhancement in intensities and width of the line at the location of RBEs. Furthermore, the broadened Si IV profile can be fitted with a double Gaussian fit with a broader component, similar to explosive events seen in Si IV. We don't see any signatures of the RBEs in AIA 171 channel. This could be due to the limited spatio-temporal resolution of the AIA channels. Therefore, the High-Resolution Imager of the Extreme Ultraviolet Imager on board the Solar Orbiter will be crucial in studying the coronal counterparts of chromospheric jets.

P53: Deb Baker – Identification of a narrow corridor as the source of slow solar wind

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From 17-20 March 2022, active region (AR) 12967 was tracked simultaneously by Solar Orbiter (SolO) at 0.35 au and Hinode/EIS at Earth. During this period, strong blue-shifted plasma upflows were observed along a thin, dark corridor of open field originating at the AR's leading polarity and running to the southern extension of the northern polar coronal hole. The morphology of the corridor was extremely stable as the AR erupted and decayed throughout its disk transit. Intensity images from emission lines ranging from Fe VIII to Fe XV show that the corridor expands with height, consistent with the expansion of the magnetic field in a PFSS model. Q-maps of the large scale topological structures further confirm this expansion in support of the S-Web theory for the slow wind. The thin corridor of upflows is identified as a source region of the solar wind detected by the MAG and SWA in situ instruments onboard SolO. The slow, low temperature, smooth and radial solar wind increases in density as SoLO crosses the wind stream originating in the corridor, as it gets closer to the AR core. As the connectivity changed from the corridor to the eastern side of the AR, the plasma parameters of the slow solar wind confirm a different source region. This second slow solar wind stream is characterized by significantly higher temperatures and electron energies accompanied by more significant fluctuations in the radial velocity, suggestive of higher Alfvenicity. In summary, the observations from SolO and Hinode/EIS provide evidence of the narrow corridor as the source region of the smooth and radial slow solar wind.

P54: Peter Wyper – The imprint of intermittent interchange reconnection on the solar wind

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It is now understood that the near-Sun solar wind is permeated by an abundance of magnetic switchbacks, yet their origin remains unclear. One idea that has attracted attention is that switchbacks could be formed by interchange reconnection in the solar corona. In this work we test this hypothesis using adaptively-refined, ultra-high-resolution, 3D MHD simulations of interchange reconnection occurring at a pseudostreamer. Surface motions are used to stress the null of the pseudostreamer, which initially collapses into a Sweet-Parker-like current layer before becoming violently unstable to plasmoid formation. We find that plasmoids repeatedly form and are ejected from the layer leading to a continual modulation of the solar wind within the stalk of the pseudostreamer. We explore the simulated in-situ and remote signatures of this modulation and find that it takes the form of many small-scale torsional Alfven wave-like perturbations but that crucially it does not include any reversals of the radial field component or clear S-shaped structures. Our study therefore suggests that although intermittent interchange reconnection at pseudostreamers could be a source of significant solar wind variability, it is unlikely to launch switchbacks directly into the solar wind.

P55: Hannah Collier – Imaging individual Gaussian contributions to the hard X-ray emission of solar flares with Solar Orbiter's STIX.

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The Spectrometer Telescope for Imaging X-rays (STIX) onboard Solar Orbiter consists of 32 energy channels which detect X-ray emission from solar flares of energies in the range of 4-150 keV. With STIX, it is possible to perform imaging spectroscopy for solar flares with a 1 keV energy resolution at an unprecedented high time cadence (0.5 s), in the hard X-ray range. This work exploits the novel capability of STIX by focusing on the investigation of fast time, oscillatory variations in the hard X-ray emission of flares. Gaining an understanding of the mechanism behind such fast time variations is pertinent for revealing the fundamental processes involved in the acceleration of electrons and ultimately for the generation of a unified solar flare model. In previous studies, HXR time series were smoothed using Gaussian process regression (GPR). The smoothed HXR time profiles were then fitted with a linear combination of Gaussians, from which key characteristics such as the time between peaks, FWHM, height and periodicity are derived. In this work, the derived information is used to spatially resolve sources and to perform time dependent spectral analysis of the individual peaks for a handful of M and X class flares observed by STIX since September 2021.

P56: Jordi Boldu – Langmuir waves associated with magnetic holes in the solar wind

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Langmuir waves (electrostatic waves near the electron plasma frequency) are often observed in the solar wind, playing an important role in the energy dissipation of electrons. The largest amplitude waves are typically associated with type II and III solar radio bursts and planetary foreshocks. However, Langmuir waves not connected with radio bursts are also found in the solar wind. The causes of these Langmuir waves are not well understood. Langmuir waves are also found around magnetic holes, a localised depression of the magnetic field strength. This study aims to investigate the relationship between Langmuir waves and magnetic holes in the solar wind using electric and magnetic field measurements performed by the Solar Orbiter's RPW and MAG instruments during 2020 and 2021. We identified a large set of Langmuir wave events from the RPW/TDS (Time Domain Sampler) waveform data using the plasma density estimated from the spacecraft's potential obtained by RPW, showing that ~10% of them have been spotted inside magnetic holes. We will compare these events with local plasma conditions analysing the electron distribution functions, and discuss the mechanisms that may lead to the generation of Langmuir waves associated with magnetic holes in the solar wind.

P57: Domenico Trotta – Multi-spacecraft observations of a strong interplanetary shock at Solar Orbiter and L1.

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In-situ observations of interplanetary (IP) shocks are fundamental to address important aspects of energy conversion in the Heliosphere, including the production of very energetic particles. We study the behaviour of an unusually strong IP shock observed on November 3rd 2021 by Solar Orbiter, at a distance of 0.8 AU from the Sun. The shock parameters are addressed for this event, revealing an oblique shock propagating in a structured portion of the solar wind. At a later time, the shock was observed by several spacecraft located at Lagrange point L1, well aligned radially with Solar Orbiter upstream. Here, the observations reveal the presence of steepened waves, associated with pre-conditioning of the incoming plasma for the shock upstream. We observe these structures at different stages of their evolution, discussing their transient nature both in space and time.

P58: Andretta, Vincenzo – Eruptive prominences in H I Ly-alpha observed with the Metis coronagraph

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During the Solar Orbiter cruise phase, Metis carried out long stretches of synoptic observations. During those synoptic programs, several coronal mass ejections were detected, some of which exhibited strong signatures of H I Ly-alpha emissions that could be attributed to eruptive prominences. We describe and discuss a few of these events observed from April to October 2021. In particular, the last of this series of events was observed by Solar Orbiter on October 28th as an Earth-bound halo CME and was associated with an X-class flare.

P59: Andy S.H. To – Understanding the Correlation between Solar Coronal Abundances and F10.7 Radio Emission

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Sun-as-a-star coronal plasma composition, derived from full-Sun spectra, and the F10.7 radio flux (2.8 GHz) have been shown to be highly correlated (r = 0.88) during solar cycle 24. However, this correlation becomes nonlinear at times of increased solar magnetic activity. Here, we use co-temporal, high spatial resolution, multi-wavelength images of the Sun to investigate the underlying causes of the non-linearity of the coronal composition (FIP bias)–F10.7 solar index correlation. Using the Karl G. Jansky Very Large Array (JVLA) radio data and Hinode/EIS (EUV Imaging Spectrometer), we observed a small active region, AR 12759, throughout the solar atmosphere from the chromosphere to the corona. Results of this study show that the magnetic field strength (flux density) in active regions plays an important role in the variability of coronal abundances, and it is likely the main contributing factor to the nonlinear correlation during increased solar activity. Coronal abundances above cool sunspots are lower than in dispersed magnetic plage regions. Strong magnetic concentrations associated with the gyroresonance component of the F10.7 radio emission seems to explain the saturation of the elemental composition of the solar corona during enhanced solar activities. The distinctly different tendencies of radio emission and coronal abundances in the vicinity of sunspots is the likely cause that sun-as-a-star coronal abundances seem to saturate during solar maximum, while the F10.7 index remains well correlated with the sunspot number and other magnetic field proxies.

P60: Alessandro Liberatore – In-flight Performance of the Metis Visible-light Polarimeter

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The Metis coronagraph is one of the remote-sensing instruments of the ESA/NASA Solar Orbiter mission. Metis is aimed at the study of the outer layer of the solar atmosphere (the solar corona) and the study of the solar wind by simultaneously acquiring images in both visible-light (broadband: 580–640 nm) and UV (narrow-band: HI Ly-α, 121.6 ± 10 nm). The visible- light channel includes a polarimeter with an electro-optically modulating Liquid Crystal Variable Retarders (LCVRs) to measure the linearly polarized brightness (pB) of the K-corona. From the pB the coronal electron density can be derived. This presentation illustrates the first in-flight assessment of the performance of the Metis polarimetric channel. The in-flight performance is compared against to the on-ground calibrations and to pB measurements from the LASCO/SOHO. The Metis polarimeter validated positively the first use in deep space (with hard radiation environment) of an electro-optical device: a LCVR.

P61: Giuliana Russano – Three CMEs observed simultaneously in Ly-alpha and visible light by Metis in September 2021

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We show three CMEs events occurred on September 2021 above the South-Est and South-West limbs of the Sun, observed by the Solar Orbiter (SolO) Metis coronagraph onboard Solar Orbiter. All events are visible in both Metis UV and Visible-Light (VL) channels, the former being a narrow-band filter around the H I Ly-alpha line at 121.567 nm and the latter sensitive to the 580 and 640 nm range.

In particular, during one of these events, a bright plasma blob most likely associated with a prominence eruption was observed in both VL and UV channels.

We present in this work the ongoing analysis to derive geometrical and physical parameters of the CMEs events.

P62: Joel Baby Abraham – Radial evolution and thermal energy density budget of thermal and suprathermal electron populations in the slow solar wind from 0.13 to 0.5 au : Parker Solar Probe observations

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We develop and apply a bespoke fitting routine to a large volume of solar wind electron distribution data measured by Parker Solar Probe (PSP) over its first five orbits, covering radial distances from 0.13 to 0.5 au. We characterize the radial evolution of the electron core, halo and strahl populations in the slow solar wind during these orbits. The fractional densities of the three electron populations provide evidence for the growth of the combined suprathermal halo and strahl populations from 0.13 to 0.17 au. Moreover, the growth in the halo population is not matched by a decrease of the strahl population at these distances, as has been reported for previous observations at distances greater than 0.3 au. We also find that the halo is negligible at small heliocentric distances. The fractional strahl density remains relatively constant ~1% below 0.2 au, suggesting that the rise in the relative halo density is not solely due to the transfer of strahl electrons into the halo.

One of the main drivers for thermal solar wind expansion is facilitated by electrons. However, the total net electron energetics is still poorly understood. We use the macroscopic properties obtained from our fits to evaluate the thermal energy equation based on the second moment of the Boltzmann equation. We find that in the inner heliosphere the electrons have an energy source that supplies thermal energy but degrades with radial distance.

P63: Susanna Parenti – Solar Orbiter EUI/HRIEUV observations of moss at high spatial and temporal resolution: are these nanoflare ribbons

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Moss regions, which are most visible in warm (~1 MK) emissions such as those detected in the AIA/SDO 171 band (Fe IX-X), are identified as the transition region footpoints of hot (~3MK) loops in the active region core. Past investigations at moderate spatial resolution revealed the moss to be dense with relatively small intensity variations, and to have a filling factor less than 1. These properties indicated two possibilities for the heating of the loops connected to the moss: (1) the loops are spatially resolved and heated in a quasi-steady fashion or by high frequency nanoflares; (2) the loops are spatially unresolved and heated by low or intermediate frequency nanoflares.

Solar Orbiter, launched in February 2020, has recently reached its first perihelion at about 0.32 AU. The observations carried out with the high temporal (3s cadence) and spatial (less than 200 km) resolution EUI/HRIEUV (174 Å) telescope has revealed interesting now properties of the moss. It is highly dynamic on small spatial scales. In this work, we investigate the idea that small, elongated emission structures that move perpendicular to the main axis may be the counterparts of spreading flare ribbons, but are associated with much smaller nanoflares. We examine the implications for the frequency of nanoflare heating.

P64: Alessandra Giunta – Measuring relative abundances in active regions with Solar Orbiter/SPICE

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With the launch of Solar Orbiter we are now able to fully explore the link between the solar activity on the Sun and the inner heliosphere. Composition measurements provide a key tracer to probe the source regions of the solar wind and to track it from the solar surface to the heliosphere.

Abundances of elements with low first ionisation potential (FIP) are enhanced in the corona relative to high-FIP elements, with respect to the photosphere. This is known as the FIP effect which is measured as abundance bias (FIP bias) of low and high FIP elements.

The comparison between in-situ and remote sensing composition data, coupled with modelling, will allow us to trace back the source of heliospheric plasma. Solar Orbiter has a unique combination of in-situ and remote sensing instruments that will help to make such a comparison.

In particular, the SPICE (Spectral Imaging of the Coronal Environment) EUV spectrometer records spectra in two wavelength bands, 70.4–79.0 and 97.3–104.9 nm, using a core set of emission lines arising from ions of both low-FIP and high-FIP elements such as C, N, O, Ne, Mg, S and Fe. These lines are formed over a wide range of temperatures from 20,000 K to over 1 million K, enabling the analysis of the different layers of the solar atmosphere. SPICE spectroheliograms can be processed to produce FIP bias maps, which can be compared to in-situ measurements of the solar wind composition of the same elements.

During the Solar Orbiter Cruise Phase and the beginning of Nominal Mission Phase, SPICE observed several active regions, acquiring a series of full spectrum images. We will present some of these observations and discuss the SPICE diagnostic potential to derive relative abundances and the FIP bias in those regions.

P65: Therese A. Kucera – Modeling of condensations in active region loops produced by nanoflares

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The presence of condensations in active regions has potential to be an important diagnostic of coronal heating. We present the results of models of nanoflare heated coronal loops using the 1-D hydrodynamic ARGOS code. The nanoflares are modeled by discrete pulses of energy along the loop. We explore the occurrence of cold condensations due to the effective equivalent of thermal non-equilibrium (TNE) in loops with steady heating, and examine the dependence on nanoflare timing and intensity and also on location of nanoflares along the loop, including of randomized distributions of nanoflares. We find that randomizing the timing and intensity of nanoflares tends to diminish the likelihood of TNE compared to regularly occurring nanoflares with the same average properties, but that TNE can sometimes occur in regimes where regular nanoflares would not produce TNE. Randomizing of the nanoflare locations also seems to reduce the occurrence of condensations. Also, the condensations stay in the loop for a shorter amount of time when the nanoflares are random. These properties can be used to investigate diagnostics of coronal heating mechanisms usable by instruments like EUI and SPICE.

P66: Fernando Carcaboso Morales – Peculiar In-Situ Signatures During the Passage of a Corotating Interaction Region by Solar Orbiter, STEREO-A and Near Earth

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During the time interval from 6 to 9 January 2022, a corotating interaction region (CIR) driven by a medium speed (~450 km/s) solar wind stream running into an even slower (~300 km/s) solar wind was sequentially observed by STEREO-A, Solar Orbiter, and near-Earth spacecraft such as ACE and Wind. All these spacecraft were located near 1 au and relatively close in longitude (STEREO-A at ~35 degrees east of Earth and at a heliographic latitude of 0 deg; Solar Orbiter ~14 degrees east of Earth and heliographic latitude -1 deg; and Earth at heliographic latitude -4 deg). Despite the slow solar wind driving this CIR, strong forward and reverse shocks bounded the CIR structure when passing near Earth generating a G1 (Kp~5) geomagnetic storm, whereas at Solar Orbiter it was preceded by just a forward shock, and at STEREO-A no clear shock signatures were observed preceding or following the CIR. The origin of the solar wind stream driving this CIR was an equatorial extension of the inward polarity southern coronal hole, which might explain the stronger CIR signatures observed by near-Earth spacecraft located at a lower heliographic latitude than Solar Orbiter and STEREO-A. Two peculiarities associated with the passage of this CIR structure are (1) the extremely distinct signatures of the ion intensity enhancements associated with the passage of the CIR at each spacecraft, and (2) a smooth field rotation observed during ~2.5 hours within the CIR at STEREO-A and Solar Orbiter but absent during the CIR passage at Earth. The ion event associated with the passage of this CIR was observed at energies below <~500 keV, with a harder spectrum at Earth. Whereas at STEREO-A >50 keV ion intensities enhanced at both the leading and trailing boundaries of the CIR with a depression during the passage of the smooth field rotation, Solar Orbiter only measured >50 keV ion intensity increases in association with the passage of the forward shock. By contrast, near-Earth spacecraft only detected intensity enhancements during the passage of the reverse shock. We discuss the possible origin of the intra-CIR smooth field rotation and the reasons for the distinct particle signatures.

P67: Jon Linker – Modeling Multi-Spacecraft SEP Events with STAT

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Solar Energetic Particles (SEPs) are typically associated with large solar eruptions that produce fast coronal mass ejections (CMEs). They are of fundamental scientific interest and can also represent a significant space weather hazard. SEP events measured at multiple locations in the heliosphere can provide us with new insights into the acceleration and transport mechanisms of SEPs. The Solar Orbiter (SolO) and Parker Solar Probe (PSP) missions offer new opportunities to study such events. These widespread events are challenging to model, as they require a global description of SEPs in the solar corona and inner heliosphere. We are investigating globally observed SEP events with STAT (SPE Threat Assessment Tool). STAT combines CORHEL (Corona-Heliosphere) magnetohydrodynamic (MHD) models of CMEs in the solar corona and inner heliosphere with EMMREM (Earth-Moon-Mars Radiation Environment Module) solutions of the Focused Transport Equation. We describe our results for several events, including those observed at both SolO and PSP.

P68: Pariat, E. – Magnetic helicity as a marker of solar eruptivity: the helicity eruptivity index

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The deterministic determination of the onset location and time of solar eruptions would represent a major breakthrough for the prediction of coronal mass ejections. Unfortunately, to this date, no single criterion has been identified that can efficiently characterize the eruptivity of solar active centers. This results from the lack of understanding of the physical mechanism that trigger solar eruptions.

Using an orthogonal approach, we recently analyzed the link between magnetic helicity and eruptivity using both numerical simulations and observations. Magnetic helicity is a physical quantity related to the level of entanglement of the magnetic field lines in a system and is one of the few invariants in ideal magneto-hydrodynamics (MHD). We have analyzed the properties of magnetic helicity in diverse series of parametric 3D MHD simulations of eruptions, resulting either from line-tied boundary forcing or from flux emergence. We observed that a quantity based on magnetic helicity was able to efficiently characterize the eruptivity of the simulated magnetic systems. This helicity eruptivity index is defined as the ratio of the non-potential magnetic helicity to the total relative magnetic helicity. Our preliminary analysis of a limited set of observed active regions also demonstrates that the helicity eruptivity index can indeed mark the eruptivity of solar active regions.

While reliable measures of magnetic helicity in observed active regions remains difficult, our analysis shows that magnetic helicity represents a promising tool to predict solar eruptions, giving insights into the key mechanisms triggering eruptions.

P69: Kostas Moraitis – How to identify important helicity locations in the Sun through field line helicity

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Magnetic helicity – the geometrical quantity that describes the twist and writhe of individual magnetic field lines, and also, the intertwining of pairs of field lines – has an important physical meaning in the study of magnetized plasmas, as it is conserved in ideal magneto-hydrodynamics. In many cases however it is desirable to be able to identify the spatial locations where magnetic helicity is more important. A meaningful way to define such a density for magnetic helicity is through field line helicity, which, in solar and astrophysical conditions, is better expressed by relative field line helicity (RFLH). The first detailed study of RFLH in the solar active region 11158 revealed that it exhibits different morphology than the other physical parameters, and thus, that it provides new information about the active region. Additionally, RFLH managed not only to reproduce the large decrease in the value of helicity during an X-class flare of the active region, but also to associate it with the flux rope that later erupted. Based on these results we highlight the necessary steps in the process of identifying the locations of significant magnetic helicity. This task can provide crucial information for the conditions of the Sun, especially around eruptive events. Use of the higher-resolution Solar Orbiter/PHI data is also expected to help towards this goal.

P70: Daniel Müller – 3D Visualisation of Solar Data with JHelioviewer

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Solar observatories are providing the world-wide community with a wealth of data, covering large time ranges (e.g. SOHO), multiple viewpoints (STEREO, Solar Orbiter), and returning large amounts of data (SDO). To help with the associated challenges of data visualisation, visual browsing, and data access, the open source software JHelioviewer has been developed as part of the ESA/NASA JHelioviewer project. In this contribution, we highlight recently added functionality, in particularly related to the visualisation of Solar Orbiter data and the mission's science operations planning during periods of short-term pointing updates.

P71: A. Burtovoi – Cross-calibration of the Metis visible light and ultraviolet detectors and the instruments of SOHO and STEREO observatories

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We present the cross-calibration of the Metis/Solar Orbiter visible light (VL) detector and the SOHO/LASCO-C2 and STEREO-A/COR2 coronagraphs. We compared the total (B) and polarized (pB) brightness images of these instruments obtained during the conjunctions of Metis with COR2 and LASCO-C2 in Nov 2020 and Nov 2021, respectively. We obtained in general a good agreement between the Metis and COR2 images both for the total and polarized brightness, especially in the equatorial regions with bright streamer structures. Since LASCO-C2 images are corrected for the stray-light (SL) background, we did calculate the SL pattern of Metis in the overlapping part of the fields of view of these two instruments. Our analysis of the polarized brightness images shows that the Metis pB maps are ~1.5-1.7 times brighter than those of LASCO-C2.

We also compared the monthly-averaged radial profiles of the HI Ly-alpha line intensity extracted from the Metis ultraviolet (UV) images acquired in 2020-2021 with those calculated using the SOHO/UVCS archive data collected during the period of the activity minimum of solar cycle 22 in 1996-1997. We found that equatorial intensity profiles are consistent with each other.

Performed cross-calibration confirms the reliability of the radiometric calibration procedure of Metis VL and UV detectors applied to the cruise phase data.

P72: Federica Frassati – Study of 28th September 2021 CME-driven shock: 3D kinematics reconstruction and plasma parameters derivation

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On 2021 September 28 around 06:00 UT a prominence erupted from an active region located in the solar west region as seen from Earth's perspective. The eruption involved a C1.6 class flare and a coronal mass ejection which was detected by three coronagraphs: SolO/Metis, STEREO-A/COR, and SOHO/LASCO.

Radio emissions related to this event were also detected by both space- and ground-based instruments in different frequency ranges. In particular, the CME associated with the eruption triggered a coronal shock wave whose presence is confirmed by the observation of Type II radio burst's fundamental and harmonic emissions.

In this work, by combining observations from different instrumentation, magnetic field simulations, and 3D electron density reconstructed using time-dependent Solar Rotational Tomography (SRT), we investigate the 3D kinematics of the expanding shock front and infer the shock physical parameters in the locations where the accelerating particle beams lead to the radio emission.

P73: Denise Perrone – Solar wind turbulence evolution in the inner heliosphere

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Turbulence in plasmas involves a complex cross-scale coupling of fields and distortions of particle velocity distributions, with the emergence of non-thermal features. How the energy contained in the large-scale fluctuations cascades all the way down to the kinetic scales, and how such turbulence interacts with particles, remains one of the major unsolved problems in plasma physics. Recently, thanks to new solar missions, it is finally possible to study the radial evolution of the solar wind as it expands in the inner heliosphere, from the solar corona out to 1 AU.

Solar wind turbulence is not homogeneous but is highly space-localized and the degree of non-homogeneity increases as the spatial/time scales decrease (intermittency). Such an intermittent nature has also been found to evolve with distance from the Sun, possible due to the emergence strong non-homogeneities of the magnetic field over a broad range of scales. Here, the nature of the turbulent fluctuations is investigated by using high-time resolution magnetic field data in different regions of the heliosphere and in different solar wind conditions. The ion scales appear to be characterized by the presence of non-compressive coherent structures, such as current sheets, vortex-like structures, and wave packets identified as ion cyclotron modes, responsible for solar wind intermittency and strongly related to the energy dissipation. Understanding the physical mechanisms that produce coherent structures and how they contribute to dissipation in collisionless plasma will provide key insights into the general problem of solar wind heating.

P74: Clementina Sasso – Multi-spacecraft Observations of a Prominence Eruption

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We report a multi-spacecraft observation of a large prominence which erupted on December 24 2021, at the NE limb of the Sun. The eruption was initially observed by the EUI/FSI instrument on board Solar Orbiter (SolO), starting at around 18:00 and last seen in the field of view (FOV) of FSI on December 25 around 03:30 UT. It could be tracked to heights of around 13 Rs, thanks to the observations of white-light coronagraphs, such as LASCO-C2 and -C3, STEREO-A/COR1 and COR2, and of the SolO Metis coronagraph. In particular, the maximum height reached by the prominence alone was around 8 Rs and it was detected in the Metis visible light (VL) channel.

The eruption was observed also by other EUV instruments like GOES-17/SUVI, STEREO-A/EUVI, PROBA2/SWAP, SDO/AIA and the above-mentioned white-light coronagraphs. Thanks to this multi-perspective view it is possible to investigate the various phases of the evolution of the prominence eruption and its structure and dynamics.

In addition, the eruption was in the direction of the PSP spacecraft whose in-situ measurements will be used to gain information on the magnetic structure of the event, eventually also relying on modeling tools.

P75: Jana Kasparova – Solar flares in multiwavelegths

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Multiwavelength observations of solar flares and their first analyses are presented. We focus on co-temporal and co-spatial events detected by STIX and optical and radio instruments of the Astronomical Institute of the CAS and data obtained by a recent campaign at GREGOR telescope on Canary Islands and IRIS-Hinode Operation Plan 422 for observation of flaring atmosphere.

P76: Štěpán Štverák – Correction methods for spacecraft potential effects in SWA-EAS measurements

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A spacecraft immersed into the solar wind is typically charged positively with respect to the ambient plasma environment by escaping photo and/or secondary electrons emitted from its surface materials. These electrons of spacecraft origin as well as the electric fields associated with the spacecraft potential can significantly distort the local plasma conditions and therefore affect any in-situ electron observations. This effect can be detrimental for the derivation of the electron properties. Here we present a preliminary assessment of these effects as observed by the SWA-EAS electron analyser in the very complex electrostatic environment of the Solar Orbiter spacecraft. We provide some characteristic properties of the parasitic electron populations and develop possible correction methods for SWA-EAS measurements to derive the unperturbed ambient plasma conditions. We compare the outcomes of our correction methods to relevant measurements acquired by two other complementary plasma instruments on board the spacecraft – SWA-PAS and RPW.

P77: Lubomir Prech – Evolution of alpha particle content at flux rope boundaries as seen by Solar Orbiter

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The solar wind is highly structured and consists of bundles of flux ropes. Their boundaries can be identified as sharp changes of the magnetic field magnitude and/or direction that are frequently accompanied with changes of plasma parameters like velocity, density and ion composition. An analysis of observations showed that flux rope diameters can range from thousands of kilometers to tenth of AU. Whereas the small ropes can be hardly distinguished from structures produced by nonlinear interaction of plasma waves, large ropes like ICMEs or MCs attract attention of scientific community for years. The velocity within these structures can significantly differ from that in the ambient wind and thus they can drive interplanetary shocks followed by highly fluctuating sheaths. The contribution is based on Solar Orbiter PAS ion spectrometer observations of one MC like structure. The good radial alignment with other spacecraft operating in the interplanetary space allows us comparison of their observations. The alpha abundance variations are usually attributed to crossings of the flux rope boundaries but we argue that the processes like the mirroring at temporary created magnetic field enhancements can lead to changes of the alpha particle relative content within a single flux rope. We show that the sheath fluctuations are complex but a careful analysis of relative alpha particle abundance can help to resolve the original flux rope structure that is masked by intrinsic sheath fluctuations.

P78: Lucie Green – Using EUI's extended field of view to study stealthy CMEs in the middle corona

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In the last decade, EUV images studying the source regions of coronal mass ejections have indicated a set of eruptions that produce little to no lower coronal signatures (e.g. flaring, dimming regions or obvious erupting structure), but which can still be geoeffective. Termed stealth CMEs, some of these events have been shown to originate by the eruption of a structure located at an altitude in excess of 0.3 solar radii above the photosphere. That is, close to the lower boundary of the so-called 'middle corona' that extends from roughly 0.4 to 3 solar radii above the photosphere. This is a region in which EUV emission is usually not sufficiently strong against the background noise and at an altitude which is at the edge of some telescope's field of view (e.g. AIA). However, EUI's Full Sun Imager provides a large field of view and a good signal to noise out to around 2 solar radii above the surface. The study presented here makes use of EUI's wide field of view to study the origin of stealthy CMEs and their kinematics through the middle corona. We show observations that reveal how the eruption of a coronal cavity led to the creation of a second erupting structure. The origin and the evolution of the two eruptions are discussed against the context of a global potential field model. We also comment on how new datasets, for example those provided by EUI, are showing eruption signatures at higher altitudes than before and that the concept of the existence of 'stealth' CMEs needs to be revisited.

P79: Lucie Green – The magnetic environment of the energetic particle events of September 2017 from active region 12673

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Forecasting solar energetic particle (SEP) events, and identifying flares/CMEs from active regions that will produce SEP events in advance is extremely challenging. Gaining better knowledge of the conditions in which SEP events occur may feed into Solar Orbiter planning programmes. We present the magnetic field environment of NOAA active region 12673, including the magnetic configuration of the active region, the configuration of the surrounding magnetic field in the vicinity of the active region, the decay index profile, and the footpoints of Earth-connected magnetic field, around the time of four eruptive events. Two of these events are SEP productive and two are not. We analyse a range of EUV and white light coronagraph observations along with potential field extrapolations and find that the CMEs associated with the SEP-productive events either trigger null point reconnection that redirects flare-accelerated particles from the flare site to the Earth-connected field and/or have a significant expansion (and shock formation) into the open Earth-connected field. We show that the magnetic field environment of the source active region, the magnetic configuration in the vicinity of the active region, the propagation direction of the CME along with the magnetic field connectivity play an important role in the escape and arrival of SEPs at Earth. The magnetic field environment therefore may determine whether these particles will be detected in situ by spacecraft situated at different vantage points.

P80: Liu Yang – The suprathermal ions near the 2021 November 3rd shock

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We present a case study of the in-situ ion acceleration during the 2021 November 3 shock observed by the SolO/EPD/STEP instrument, which measures ~4-60 keV ions in 1s time resolution with 15 pixels each covering a field of view of 10°×12°. We find that suprathermal ion fluxes peak from ~12 to 24 s before the shock in the upstream with increasing velocities from 1000 to 3000 km/s in the solar wind frame. Those fluxes decrease by half in a thin layer between the shock front and ~15 s after the shock in the downstream, and then become constant further downstream, suggesting that the strongest acceleration occurs in the vicinity of the shock front. Moreover, the downstream ions fluxes at 1000 to 3000 km/s generally fit well to a double-power-law, J ~v-β, with an index of β1~2.9 at velocities below a break at ~1700 km/s and β2~4.0 at velocities above. However, the suprathermal ion spectrum in the close upstream appears to show a bump around 1700 km/s superimposed on a double-power-law spectrum with a β1~1.9 at ~1000-1500 km/s and β2~3.9 at velocities above 1800 km/s. These indices are all significantly smaller than the prediction by diffusive shock acceleration. In addition, the pitch-angle distributions of downstream suprathermal ions show anisotropies towards 90°, while the upstream ions show anisotropic beams traveling away from the shock in the close upstream and become nearly isotropic further upstream. These results suggest that the diffusive shock drift acceleration may play an important role in accelerating suprathermal ions at interplanetary shocks in the inner heliosphere.

P81: Vratislav Krupar – Type III bursts observed by Solar Orbiter, Parker Solar Probe and STEREO-A during a Radial Alignment in September 2021

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Type III bursts are a consequence of impulsively accelerated electrons associated with solar flares. They are generated when beams of suprathermal electrons interact with ambient plasma generating radio emissions at the plasma frequency or its second harmonic. Recent results suggest that the characteristic exponential decay profile of type III bursts could be solely explained by the scattering between the source and the observer. Here, we report a rare instance of two type III bursts from September 2021 observed by Solar Obiter, Parker Solar Probe and STEREO-A, when the three spacecraft were nearly radially aligned and orbiting near 0.60 au, 0.76 au, and 0.96 au, respectively. We investigate the characteristic exponential decay profile for common frequency channels. We have found an agreement between the three spacecraft. This indicates that scattering—if responsible for long exponential decays—occurs primarily near sources, and radio waves propagate along straight lines afterward.

P82: Gaetano Zimbardo – Detection of a coronal mass ejection by the Metis coronagraph on the far side of the Sun

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A few days before the Solar Orbiter perihelion of March 26, 2022, the Metis coronagraph detected a coronal mass ejection (CME), apparently emerging from the north polar region. Indeed, on March 22, from 20:15 UT onwards, Metis showed a CME propagating in the northern field of view of the instrument. This CME was actually traveling away from the far side of the Sun (with respect to Solar Orbiter) at relatively high northern latitudes.

Considering the positions of various spacecraft on March 22, 2022, it is found that no spacecraft was on the opposite side of Solar Orbiter to make in-situ measurements of the interplanetary CME and/or of the associated energetic particles, but several remote observations were obtained. In particular, the CME of March 22 is well within the field of view of STEREO-A/SECCHI, and is visible over the limb from SoHO/LASCO; also, indications of the activity associated with the CME were possibly seen by the WISPR instrument aboard Parker Solar Probe.

Here, we make a survey of the available data, show different views of the CME by different spacecraft, try to identify a possible source region of the CME on the far side, and present some preliminary results on the 3D reconstruction of the CME.

P83: Rossana De Marco – An Innovative Technique for Separating Proton Core, Proton Beam and Alpha Particles in Solar Wind 3D Velocity Distribution Functions

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The identification of proton core, proton beam and alpha particles in solar wind measurements, crucial for the comprehension of the kinetic processes which take place in the plasma, is usually performed applying specific fitting procedures to the particle energy spectra. However, in many cases this turns out to be a challenging task, due to the overlapping of the curves. We developed an alternative method for separating the particle families, based on the statistical technique of clustering. Clustering is a standard tool in many data-driven and machine learning applications. We show that our technique, applied to the 3D velocity distribution functions measured by an electrostatic analyzer, proves to be very promising in solving difficult cases of identification of particle species in solar wind measurements.

P84: Gabriel Ho Hin Suen – Estimates for the Time and Length Scales of Switchback Dissipation Through Magnetic Reconnection as Observed by Solar Orbiter

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Magnetic switchbacks are localized polarity reversals in the heliospheric magnetic field, lasting anywhere between a few seconds to a few hours. Observations from Parker Solar Probe (PSP) have shown that they are a prevalent feature of the near-Sun solar wind. However, observations of switchbacks at 1 AU and beyond are less frequent, suggesting that these structures are being dissipated by a yet-to-be identified mechanism as they propagate away from the Sun with the solar wind. Orbiting between 0.3–1 AU, the Solar Orbiter spacecraft is well-placed to fill in the observation gap between PSP and near-Earth spacecraft. In this case study, we use solar wind plasma and magnetic field observations from the SWA and MAG instruments to identify a magnetic switchback during Solar Orbiter's third orbit of the Sun at a distance of 0.7 AU on 10 August 2021. A reconnection exhaust with properties consistent with the Gosling bifurcated reconnection current sheet model was observed at its trailing edge boundary. We then estimate the timescale over which this switchback is dissipated by reconnection and find it to be much shorter compared to the expansion timescale. The observed event here is evidence supporting the viability of magnetic reconnection as a dissipation mechanism for magnetic switchbacks and shows that dissipation occurs well before they reach Earth, thus explaining the rarity of switchback observations at 1 AU.

P85: E. Kraaikamp – The highest resolution full disc EUV corona image ever

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On March 7 2022 with Solar Orbiter at a distance of 0.50 AU to the Sun and crossing between the Sun and Earth line, the Extreme Ultraviolet Imager (EUI) with its High Resolution Imager in EUV (HRI-EUV, 17.4 nm) created a 25-panel mosaic of raw exposures covering the entire disc of the Sun. Using this dataset we discuss the biggest challenges of calibrating EUI data in general and HRI-EUV data in specific: from dark and flat calibration, artefacts on the detector in the shape of gummy bears, to the difficulties in combining low and high-gain images into high dynamic range combined gain exposures. Finally, we show how the calibrated images were combined into the highest resolution full-disc solar corona image in Extreme ultraviolet light ever.

This combined mosaic image was produced in first instance for outreach purposes. However, some science use and multi-instrument cross-calibration can also be anticipated and we will discuss the limitations and opportunities for this.

P86: Julius Koza – Bayesian analysis of a prominence eruption observed by the Solar Orbiter EUI/FSI imager and at the Mauna Loa Solar Observatory

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The release of a coronal mass ejection (CME) may trigger a sequence of post-CME events like, for example, coronal plasma blobs. Comprehensive observations of the parent CME and subsequent events are crucial for proving their causal coupling, if any. On February 12, 2021 a typical slow CME was followed about seven hours later by a nearby prominence eruption and a trailing plasma blob confined in the post-CME current sheet. The space and ground observations of the events are presented in the contribution and paper by Bemporad et al. (2022). Here we aim at investigating the prominence data acquired by the K-Cor coronagraph at the Mauna Loa Solar Observatory and by the Solar Orbiter EUI/FSI imager. The Levenberg-Marquardt least-squares minimization technique and the Bayesian analysis, implemented in the Solar Bayesian Toolkit (SoBAT), are used to analyze the prominence expansion, captured by the K-Cor coronagraph. The latter technique allows reliable estimation of uncertainties of the model parameters and the assessing of the adequacy of the adopted model function in comparison to other function(s). The Levenberg-Marquardt technique shows modest acceleration of 3.5 ms^{-2} of the prominence front with the initial and terminal velocities of 22 and 51 kms^{-1} with the average of 37 kms^{-1} over the distance of $3.2x10^5$ km and the time span of two and half hours. The results, inferred from the K-Cor data, are re-examined by the SoBAT. We will attempt to infer the expansion parameters of the prominence from the EUI/FSI and Metis data by both techniques as well.

P87: Andrew Walsh – Ancillary and Ephemeris Data for Solar Orbiter

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The Solar Orbiter SOC, together with the ESA SPICE Service, is responsible for providing Ancillary and Ephemeris data for the mission to the instrument teams and the broader scientific community, making available the orbit, spacecraft pointing and attitude in various ways. Ancillary data are provided based on the NAIF/SPICE toolkit and as CDF files. They are distributed through the Solar Orbiter Archive as well as via dedicated channels. Here we will introduce the various predicted and as-flown ancillary data products that are available, where to get them, and some tips and tricks to make the most of the available data.

P88: Tom Van Doorsselaere – Nonlinear Damping of Standing Kink Waves Computed With Elsässer Variables

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Previously, we computed energy cascade rates for non-linear evolution of kink waves with Elsässer variables. In this talk, we focus on the standing kink waves, which are impulsively excited in coronal loops by external perturbations. We present an analytical calculation to compute the damping time due to the nonlinear development of the Kelvin-Helmholtz instability. The main result is that the damping time is inversely proportional to the oscillation amplitude. We compare the damping times from our formula with the results of numerical simulations and AIA observations. In both cases we find a reasonably good match. The comparison with the simulations shows that the nonlinear damping dominates in the high amplitude regime, while the low amplitude regime shows damping by resonant absorption. In the comparison with a damped kink wave catalog from AIA observations, we find a power law inversely proportional to the amplitude η^{-1} as an outer envelope for our Monte Carlo data points. We look forward to how this theory for non-linear damping of kink waves can be applied in Solar Orbiter.

P89: Oleksiy Dudnik – STIX (remote) and EPD observations of particles accelerated in selected events.

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The flaring solar activity in the upper solar atmosphere is characterized by both short-term and long-lived electromagnetic emissions in different wavelengths, including hard X-rays. Non-thermal part of a solar flare X-ray spectrum arises due to energetic electron beams penetrating denser parts of solar chromosphere due to Coulomb collisions (bremsstrahlung). The Spectrometer Telescope for Imaging X-rays (STIX) provides X-ray spectroscopy of thermal and non-thermal emissions up to the energy of 150 keV by using CdTe detectors. Interpretation of STIX observations provides us rich diagnostics of non-thermal electrons that are accelerated above ~10 keV during solar flares. To understand better which parameters in the STIX data may contain the information about accelerated high-energy particles, we performed a prompt cross-analysis of STIX and EPD data. In this respect, the C4 and C6 GOES class solar flares on May, 9 and 22 were selected, as examples. Particle fluxes spectrograms derived from the Electron Proton Telescope (EPT) data of the Energetic Particle Detector (EPD) suite were investigated, observed at various phases of X-ray flares as recorded by STIX. Peculiar features in the behavior of sub-relativistic electrons are being discussed such as narrow in energy and time beams, strong anisotropy of latter in velocity, presence of accelerated ions in a wide range of atomic mass for the 22 May flare event. From the STIX spectrogram data, we derived parameters of the non-thermal part of solar flare spectra. Estimated values of power-law index, energy cutoff, and total energy contained in energetic electrons were compared to counterpart values characterizing electron spectra recorded by EPD. Such face-to-face comparison allows us to show and discuss similarities and differences in both flare-related particles populations i.e., those propagating down from corona to denser layers and that escaping the Sun towards interplanetary space.

P90: Georgios Nicolaou – Constructing electron velocity distribution functions from fully calibrated SWA-EAS observations and deriving their bulk parameters

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The Solar Wind Analyser's Electron Analyser System (SWA-EAS) provides the electron measurements required to construct full three-dimensional (3D) velocity distribution functions (VDFs) of the solar wind electrons. We construct 3D VDFs first in the instrument reference frame. We then use the magnetic field measurements that are obtained simultaneously from the magnetometer (MAG) onboard the spacecraft to transform the VDFs in a field-aligned reference frame. Since the plasma particles are often organized by the magnetic field direction, these field-aligned distributions are crucial for studies of dynamic plasma processes. For instance, the study of wave particle interactions and turbulence strongly depends on these VDFs which are ideal to reveal temperature anisotropies, field aligned beams, and other kinetic structures.

In this presentation, we explain our procedure to calibrate the raw observations to produce accurate velocity distribution functions and the corresponding pitch-angle distributions of the plasma electrons. Our effort focuses on the proper characterization of the sensor response, the cross-calibration of our sensors with other instruments onboard, and the proper treatment of the spacecraft potential.

We show examples of constructed VDFs in different solar wind structures, such as shocks and high-speed streams. Finally, we explain our plan to derive the bulk parameters of the constructed distributions estimating the plasma density, flow velocity, and temperature.

P91: Malte Broese – Temperature and differential emission measure evolution of a limb flare on 13 January 2015

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Spatially unresolved observations show that the cooling phase in solar flares can be much longer than theoretical models predict. It has not yet been determined whether this is also the case for different subregions within the flare structure. We aim to investigate whether or not the cooling times, which are observed separately in coronal loops and the supra-arcade fan (SAF), are in accordance with the existing cooling models, and whether the temperature and emission measure of supra-arcade downflows (SADs) are different from their surroundings. We analysed the M5.6 limb flare on 13 January 2015 using SDO/AIA observations. We applied a differential emission measure (DEM) reconstruction code to derive spatially resolved temperature and emission measure maps, and used the output to investigate the thermal evolution of coronal loops, the SAF, and the SADs. In the event of 13 January 2015, the observed cooling times of the loop arcade and the SAF are significantly longer than predicted by the Cargill model, even with suppressed plasma heat conduction. The observed SADs show different temperature characteristics, and in all cases a lower density than their surroundings. In the limb flare event studied here, continuous heating likely occurs in both loops and SAF during the gradual flare phase and leads to an extended cooling phase.

P92: Ryan M. Dewey – In situ plasma composition of Oct-Nov 2021 ICMEs: HIS observations of prominence material

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The Heavy Ion Sensor (HIS) onboard Solar Orbiter observed the passage of multiple interplanetary coronal mass ejections (ICMEs) during late October to early November 2021. These ICMEs varied in their speed, magnetic field structure, and – as measured by HIS – their plasma composition. We present measurements of low charge state heavy ions, which appear only during a 1-hour interval within the first event, and compare these composition signatures against the other ICMEs during this time period. Such observations of prominence plasma are rare and present unique opportunities to study ICME formation, eruption, internal structure, and evolution.

P93: Nicolas Wijsen – Modelling the influence of a stream interaction region on a gradual solar energetic particle event

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We present simulation results of a gradual solar energetic particle (SEP) event detected on 9 October 2021 by multiple spacecraft located within a heliolongitudinal range of less than 50 degrees, including Solar Orbiter (SolO), Parker Solar probe (PSP), STEREO-A, BepiColombo (Bepi), and near-Earth spacecraft such as the Advanced Composition Explorer (ACE). We use the magnetohydrodynamic model EUHFORIA (EUropean Heliospheric FORecasting Information Asset) to model both the interplanetary context where this event occurred, that was characterised by the presence of solar wind stream interaction regions (SIRs), and the propagation of the coronal mass ejection (CME) that originated the SEP event. We combine the EUHFORIA results with the energetic particle transport model PARADISE (PArticle Radiation Asset Directed at Interplanetary Space Exploration) to model the acceleration of energetic protons and their transport through the EUHFORIA solar wind. A particularity of this event is that Bepi and SolO shared a nominal magnetic connection to the shock driven by the CME, but the particle enhancements observed at both spacecraft showed different features. In particular, for energies below 5 MeV, the energetic ions detected by Bepi resembled more closely the intensity-time profiles observed by ACE, while both spacecraft were approximately radially aligned at the time of the solar eruption. During this SEP event, both spacecraft observed the passage of an SIR a few hours prior to the arrival of the CME. Our simulation results illustrate the potential impact that intervening large-scale structures may have in shaping the observed properties of SEP events.

P94: Cis Verbeeck – Start analyzing EUI data today!

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With its three telescopes (Full Sun Imager FSI and High Resolution Imagers HRIEUV and HRILYA), EUI on Solar Orbiter is imaging from the largest scales in the extended corona down to the smallest features at the base of corona and chromosphere.

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 the structure and evolution of the far corona to unprecedented distances from the Sun (with transients being tracked up to 6 solar radii).

EUI's unparalleled spatial and temporal resolution naturally leads to discovery of new structures at previously inaccessible scales, such as the small-scale EUV brightenings nicknamed "campfires". During its first close perihelion in March 2022, EUI has achieved the highest resolution images ever of the solar corona in quiet Sun and polar coronal holes, while active regions were imaged at unmatched cadences and sequence durations.

This poster aims to show researchers the way to EUI observations and data analysis. After a comprehensive overview of the instrument and its abilities, the power of JHelioviewer will be employed to explore the richness of EUI data, in combination with data from other instruments.

Using examples, the reader will be directed to the FITS files in the latest EUI Data Release. EUI's open data policy invites interested researchers to work with EUI data from the moment they are available on the ground.

The poster ends with a warm invitation to issue a proposal for the first EUI Guest Investigator Call, which allows selected researchers to spend a few weeks with the PI team at the Royal Observatory in Brussels to obtain expert knowledge on the instrument, to participate in the planning of observations according to the needs of their proposal, and to conduct their research.

P95: Milan Maksimovic – The baseline solar wind observed by Parker Solar Probe, Helios, Ulysses and Voyager 1&2

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Recently Bale et al. (2022) have highlighted, using Parker Solar Probe (PSP) data close to the Sun, the existence of a baseline wind which represents the solar wind whose speed is minimum at a given radial distance. On top of this baseline wind is added a more patchy wind constituted of distinct streams that are organized on angular scales comparable to that of solar supergranulation convection scales at the surface of the Sun.

In this study we analyse solar wind data from multiple probes, from a minimum radial distance of 15 solar radii (PSP) to 75 astronomical units (Voyager 2) and show that the baseline solar wind extends to very large distances and reaches a terminal speed of about 350 km/s. We discuss the origin of this baseline solar wind in the frame of both fluid and exospheric models.

P96: Stefan Purkhart – A multi-instrument study of the M4-flare on March 28th, 2022

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We present results from multi-instrument observations of the M4-class flare on March 28th, 2022, and its associated filament eruption. We focus on remote sensing observations from the Spectrometer Telescope for Imaging X-rays (STIX) and the Extreme-Ultraviolet Imager (EUI) onboard Solar Orbiter and combine them with data from STEREO-A/EUVI+COR2 and SDO/AIA.

Solar Orbiter was close to its first perihelion of the nominal science phase, at a distance of 0.33 AU and at a longitudinal separation of 83.5° from the Earth-Sun line, and observed the Earth-directed event close to the east limb.

Imaging of the STIX hard X-ray observations and comparison with EUI images reveals non-thermal (25-50 keV) emissions from two footpoints and thermal (4-10 keV) emissions from the flare loops. We perform spectral fitting to derive the time evolution of critical parameters of the electron populations.

Emission measure (EM) and temperature derived from the thermal component of the STIX hard X-ray spectrum are compared to results from GOES and Differential Emission Measure (DEM) analysis of extreme ultraviolet (EUV) images from AIA. We find good agreement for the overall time evolution between all three instruments, with exact values varying due to different temperature responses. STIX observed a lower peak EM (0.7×10^{49} cm^{-3}) compared to AIA (1.4×10^{49} cm^{-3}) and GOES (1.6×10^{49} cm^{-3}), while the peak temperature is higher (22 MK) compared to AIA (14 MK) and GOES (16 MK).

We track the erupting filament throughout an EUI 304 Å image series. Observations from STEREO-A/EUVI are used to perform 3D reconstructions of the filament at coinciding timesteps and to fill in the gaps between available EUI images (10 min cadence). We derive speed and acceleration profiles and find a maximum ejection speed of about 580 km/s. Using data from STEREO-A/COR2, we track the CME and its core identified as the ejected filament to a distance of almost 20 solar radii.

P97: Frédéric Auchère – Pre-flight calibration of the full sun channel of the Extreme Ultraviolet Imager on board Solar Orbiter

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FSI, the Full Sun Imager, is an extreme ultraviolet (EUV) solar imager centered simultaneously on the Fe IX/X 17.4 nm and He II 30.4 nm emission lines, part of the Extreme Ultraviolet Imager (EUI) instrument on-board the Solar Orbiter mission planned to be launched in February 2020. The global efficiency of the instrument over the whole EUV wavelength range from 1 to 100 nm must be determined with the extended spectral response of its subsystems: the entrance pupil, the aluminum entrance filter, the Al/Mo/SiC dual-band multilayer mirror, and the Al/Zr/Al and Al/Mg/Al focal filters. We will discuss the uniformity of the spectral responses as well as the expected image quality and the effects of stray-light and distortion. Filters and mirror references as well as the whole instrument efficiencies have been measured on beamlines over different wavelength ranges at PTB and SOLEIL synchrotrons. We used the available data coupled with the best EUV simulations for each optical component to determine the most reliable spectral response for FSI.

P98: Frédéric Auchère – Enhancement of Solar Images with Wavelet Optimized Whitening

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Due to its physical nature, the solar corona exhibits at all wavelengths large intensity variations, which make it difficult to visualize simultaneously the features present at all levels and spatial scales. Many general purpose and specialized filters have been proposed to enhance coronal images. However, most of them require the ad-hoc tweaking of parameters to produce subjectively 'good' results. Our aim was to develop a general purpose image enhancement technique that would produce equally 'good' results, but based on an objective criterion. The underlying principle of the method is the equalization, or whitening, of power in the 'à trous' wavelet spectrum of the input image at all scales and locations. An edge-avoiding modification of the 'à trous' transform that uses bilateral weighting by the local variance in the wavelet planes is used to suppress the undesirable halos otherwise produced by discontinuities in the data. The proposed filter produces sharp and contrasted output. It is robust against a wide variety of EUV and white light images of the solar corona, without requiring the manual adjustment of parameters. Furthermore, the built-in denoising scheme prevents the explosion of high-frequency noise typical of other enhancement methods, without smoothing statistically significant small scale features. The standard version of the algorithm is about two times faster than the widely used MGN. The bilateral version is slower, but provides significantly better results in the presence of spikes or edges. Comparison with other methods suggest that the whitening principle corresponds to what most users consider visually pleasing results.

P99: Samuel R. Grant – Solar Orbiter's December 2021 encounter with the ion tail of comet Leonard

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When the solar wind encounters a comet, the gases that are released from the nucleus are ionized and propagated away with the solar wind, forming the ion tail of the comet. Spacecraft can encounter these tails, providing a rare insight into the comets' composition and disruption of the solar wind flow. Serendipitous crossings by spacecraft of comets' ion tails are a surprisingly commonplace occurrence, but can go unnoticed, as any measured plasma fluctuations can be small.

Using the measured flow of the solar wind at the spacecraft, we can estimate the motion of the solar plasma upstream of the spacecraft, and compare this trajectory with the locations of known comets. This method can uncover previously unnoticed ion tail encounters and predict future encounters.

In December 2021, while comet C/2021 A1 (Leonard) traversed the ecliptic plane, sunward of the spacecraft Solar Orbiter, the spacecraft was immersed in the comet's ion tail. This encounter was predicted using a range of estimated solar wind velocities to estimate the motion of solar wind plasma to the spacecraft. A wealth of data was collected during the encounter, including results from multiple instruments that support the prediction. We present data returned from the SWA and magnetometer instruments, providing information on the structure and orientation of the induced magnetotail. This includes evidence of the magnetic field draping around the comet, disruption of suprathermal electron flows, and possible shocks associated with the tail boundaries. Additionally, we provide a comparison with magnetic field data from nearby spacecraft that did not cross the ion tail.

P100: Immanuel Christopher Jebaraj – Multi-wavelength study of an energetic electron event on October 9, 2021 observed by Solar Orbiter

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We study the solar energetic particle (SEP) event observed on October 9, 2021, by multiple spacecraft including Solar Orbiter (SolO). The event was associated with an M3.7 flare, a coronal mass ejection (CME) and a shock wave. During the event, high-energy protons and electrons were recorded by multiple instruments located within a narrow longitudinal cone. An interesting aspect of the event was the multi-stage particle energization during the flare impulsive phase and also what appears to be a separate phase of electron acceleration detected at SolO after the flare maximum. We utilize SEP electron observations from the Energetic Particle Detector (EPD) and hard X-ray (HXR) observations from the Spectrometer/Telescope for Imaging X-rays (STIX) on-board SolO, in combination with radio observations at a broad frequency range. We focus on establishing an association between the energetic electrons and the different HXR and radio emissions associated with the multiple acceleration episodes.

We will present our first results showing that the flare was able to accelerate electrons for at least 20 minutes during the non-thermal phase observed in the form of five discrete HXR pulses. We also show evidence pointing at the possibility that the shock wave has contributed to the electron acceleration during and after the impulsive flare phase. The detailed analysis of EPD electron data shows that there was a time difference in the release of low- and high-energy electrons and also that the electron anisotropy characteristics were different during the separate phases of electron energization.

P101: David Lario – Influence of Large-Scale Interplanetary Structures on the Propagation of Solar Energetic Particles: The Multi-Spacecraft Event on 2021 October 9

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An intense solar energetic particle (SEP) event was observed on 2021 October 9 by multiple spacecraft distributed near the ecliptic plane at heliocentric radial distances R<~1 au and within a narrow range of heliolongitudes. A stream interaction region (SIR), sequentially observed by Parker Solar Probe (PSP) at R=0.76 au and 48 deg east from Earth (i.e., E48), STEREO-A (at R=0.96 au and E39), Solar Orbiter (SolO; at R=0.68 au and E15), BepiColombo (at R=0.33 au and W02), and near-Earth spacecraft, regulated the observed intensity-time profiles and the anisotropic character of the SEP event. PSP, STEREO-A and SolO detected strong anisotropies at the onset of the SEP event, which resulted from the fact that PSP and STEREO-A were in the declining-speed region of the solar wind stream responsible for the SIR, and from the passage of a steady magnetic field structure by SolO during the onset of the event. By contrast, the intensity-time profiles observed near-Earth displayed a delayed onset at proton energies >~13 MeV and an accumulation of <~5 MeV protons between the SIR and the shock driven by the parent coronal mass ejection (CME). Even though BepiColombo, STEREO-A, and SolO were nominally connected to the same region of the Sun, the intensity-time profiles at BepiColombo resemble those observed near Earth, with the bulk of low-energy ions also confined between the SIR and the CME-driven shock. This event exemplifies the impact that intervening large-scale interplanetary structures, such as corotating SIRs, have in shaping the properties of SEP events.

P102: Shane Maloney – stixpy - a python STIX data analysis package

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stixpy is the python analysis package for SolarOrbiter/STIX. stixpy provides the capabilities to search, download and analyse STIX data (e.g quicklook, housekeeping, science). The search and download capabilities build upon and integrate with sunpy's unified search and download interface Fido providing a familiar interface for users. STIX data analysis can be broadly split into three categories, quicklook, housekeeping and science. For both quicklook and housekeeping data stixpy provides many features for example concatenation of multiple files, underlying data access and standard plots. Science data analysis is based on pixel data and stixpy provides a unified view of the different levels of pixel data (raw, compressed, summed + compressed and spectrogram) and many convenience methods to plot times series spectrograms and pixel data. Science data analysis can be broken down into two areas: spectroscopy and imaging. stixpy supports standard spectral fitting methods and solar models through the sunxspex package. Visibility based imaging algorithms are provided by the xrayvision package while stixpy also implements some count based methods. Imaging spectroscopy methods are currently being developed alongside instrument calibration efforts. stixpy follows the conventions and norms of the larger SunPy and Astropy ecosystems as such it should provide a familiar "look and feel" to users of ecosystems.

P103: Alain J. Corso – Observation of comet C/2021 A1 (Leonard) with Metis coronagraph: first results

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Comet C/2021 A1 (Leonard) is a long-period comet (LPC) officially discovered on January 3, 2021 and it reached its perihelion at q=0.615 au on 2022 January 3, exactly one year after its official discovery. In addition to the ground-based observations, a serendipitous opportunity to study this comet came in mid-December 2021, when the comet crossed the field of view (FoV) of the Metis coronagraph aboard the ESA Solar Orbiter (SolO) mission. Metis coronagraph was able to observe the comet in a temporal window of about 12 hours, from 19.00UT on December 15 to 7.00UT on December 16. Exploiting the potentialities of Metis, simultaneous imaging in linearly polarized visible light (VL, 580–640 nm) and ultraviolet (UV) around the HI Lyman-α (121.6 nm) spectral line has been performed. Such observations constitute the first-ever concurrent images of an LPC in such two spectral ranges, allowing the simultaneous study of the dust and neutral hydrogen coma. The UV coma irradiance profile has been fitted by using the Haser model, allowing to estimate the water production rate and the cometary nucleus radius. The comparison of both VIS and UV images has allowed determining the difference between the hydrogen and dust coma dimension. The results obtained from the acquired data are reported.

P104: Philipp Löschl – Multi-view magnetic synoptic maps with SO/PHI and SDO/HMI

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With the first SO/PHI data being available, it is now possible to simultaneously observe the Sun from an additional vantage point off the Earth-Sun line. This opens the opportunity for joint observational campaigns with similar instruments such as the Heliospheric and Magnetic Imager (HMI) on board the Solar Dynamics Observatory (SDO). We utilise this to produce combined magnetic synoptic maps from line-of-sight magnetograms of the SO/PHI-FDT and SDO/HMI instruments. Building on the existing software infrastructure for HMI synoptic maps, we extended its current functionality to include SO/PHI-FDT data and correct for the different orbital and observational characteristics of the two spacecraft. The results are joint magnetic synoptic maps, that can be produced significantly faster than the approximately 27 days of one solar rotation and therefore are less likely to suffer from the evolution of the magnetic field over the observation period.

In this work, we discuss the challenges and limitations that arise from the substantially different operational environments of the two instruments and give an outlook on what to expect from this novel data product.

P105: Astrid M. Veronig – Multi-instrument study of two microflares observed by STIX onboard Solar Obiter

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During its commissioning phase in 2020, the Spectrometer Telescope for Imaging X-rays (STIX) on board Solar Orbiter observed dozens of microflares. The two largest ones, of GOES class B2 and B6, were observed on-disk from Solar Orbiter as well as from Earth. We present an analysis of these two events in terms of their spatial, temporal, and spectral characteristics using STIX/SO, AIA/SDO and GOES. We reconstruct differential emission measure (DEM) maps from AIA to study the time evolution of the plasma response to the energy deposition by the flare-accelerated electrons, separately in the flare kernels and loops. STIX spectra were analysed to determine the nonthermal characteristics of the accelerated electrons.

The STIX data show clear nonthermal emission for both microflares under study. For both events, the plasma temperature and EM derived from STIX and GOES as well as the reconstructed DEM maps differ in absolute values and timing, with AIA (sensitive to lower plasma temperatures than STIX) lagging behind. For the B6 event, for which such an analysis was possible, the non-thermal energy deduced from STIX roughly coincides with the lower estimates of the thermal energy requirement deduced from the SXR and EUV emissions. The observed Neupert effect and the impulsive and gradual phases indicate that both events are consistent with the standard chromospheric evaporation flare scenario. For the B6 event on 7 June 2020, this interpretation is further supported by the temporal evolution seen in the DEM profiles of the flare ribbons and loops. For this event, we also find that accelerated electrons can roughly account for the required thermal energy in the hot flaring plasma.

P106: Davide Calabrese – Metis Operations Facility: scientific Ground Segment operations for the Metis coronagraph

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The Metis Operation Facility (MOF) consists of several ground-based components allowing the Metis Instrument Science Team to manage and execute the Metis coronagraph operations in its all Mission Phases.

In particular, MOF is designed to support all end to end data processing flows: it manages the retrieval and the archival of the raw telemetry packets downlinked from the spacecraft on a daily basis, it implements dedicated pipelines for the generation of science products and it handles their distribution to the scientific community.

MOF is composed by four major elements, also called sub-systems (S/S):

- The Mission Database S/S, which implements the data archival, data access and data distribution functions. It is specifically designed to handle the large volume of all mission products data and metadata.
- The Data Processing S/S, which integrates all the pipelines for the generation of the scientific products. Its architecture guarantees reliability and proper management of the processing workload, enhancing science return.
- The Planning S/S, whose main objective is the generation of the Command Request Files, through which all activities and tasks are scheduled on-board. The system is designed to collect and provide the user with all mission constraints affecting the mission timeline, hence leaving the focus on the planning of scientific activities.
- Telemetry Monitoring S/S, which integrates several data systems for telemetry data decoding, archival, visualisation and analysis. It provides several user interfaces for on-board events and actions monitoring.

Moreover, MOF plans to integrate the Metis Reference Model, enabling the possibility of performing end to end hardware-in-the-loop simulations.

MOF is developed and maintained by ALTEC in Turin, supporting the ground segment operations for Metis instrument in close collaboration with Metis Instrument Team, ESA's Solar Orbiter SOC and MOC.

P107: Andrew Inglis – Joint X-ray observations of pulsations in a limb flare with GOES, Fermi, and STIX.

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The solar flare of 2021 December 5 was located behind the west limb of the Sun, and exhibited evidence of quasi-periodic pulsations (QPP) in X-rays observed by GOES/XRS, Fermi/GBM, with an approximate period of P ~70s. Co-incident X-ray observations were also made by the STIX instrument on board Solar Orbiter, which was located at approximately 1 AU and trailing the Earth location by approximately 2.5 degrees at this time. STIX also observed significant X-ray emission but showed only weak evidence of the same QPP structures. SDO/AIA context observations show that only high temperature plasma is visible above the solar limb from the Earth viewpoint. We investigate the effect of the viewing angle on the ability to detect QPPs in limb flare coronal plasma, finding that a pulsating X-ray source less than 1 Mm above the limb from the Earth view may have been obscured from the STIX perspective. We further explore how using stereoscopic joint observations from Solar Orbiter and Earth-based instrumentation could allow us new opportunities to constrain the locations of coronal pulsations during future limb flares.

P108: Francesco Frascella – Data Quality and Instrument Performance Monitoring for the Metis Instrument

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The aim of our work is to establish a reliable procedure for the characterization of data product quality of the Metis coronagraph on board Solar Orbiter. The data quality assessment, relevant for both in-orbit instrument performance and ground data processing, is an important task to continuously monitor and improve the scientific data products.

Metis acquires remote sensing measurements of the solar corona emissions captured in visual light (VL) and ultraviolet (UV) channels. Additionally, other objects are observed by Metis during their transit in the coronagraph field of view, for instance: planets, comets, stars, and cosmic rays.

We designed and implemented a procedure of data quality assessment based on the analysis of level-zero (L0) light-curve (LC) data products. LC data products are divided in 8 subsets, one for each coronal sector, and each data point in the LC products is computing by averaging on board 4 consecutive VL polarized-brightness acquisitions. Also, LC are downloaded by default as low latency data, thus allowing a summary of the VL acquisition with the shortest possible transmission delay. Our procedure consists in the statistical analysis of LC acquisitions, by considering the dependence on orbit phase and solar activity. In particular, we studied the fluctuations of the LC intensity to investigate the presence of threshold values that act as “flags” for the data quality assessment.

Ultimately, this procedure will support further analyses for scientific applications, such as on-board detection of particular events, but it could also represent a useful tool for next generation experiments.

P109: Ewan Cameron Mackenzie Dickson – Progress in STIX Spectroscopy: Intense Flares & Joint XSM Observations

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The Spectrometer Telescope for Imaging X-rays (STIX) is Solar Orbiter's Hard X-ray detector. It uses 32 CdTe pixelated detectors to measure the spectrum of solar flares in 32 energy bands in the range 4 - 150 keV with an energy resolution of up to 1 keV and a cadence of up to 0.5 seconds. This allows us to characterise both the hot thermal flaring plasma and the non-thermal accelerated electrons which emit X-rays by bremsstrahlung. The spectra over all detectors is commonly combined into a single specially integrated data product allowing spectral fitting of flares with insufficient intensity to image. Thus it has the ability to characterise flares from the microflare regime to the largest observed.

The use of Rate Control Regimes (RCR) allows the study of the most intense flares through the use of an Aluminium attenuator in the first instance and by switching off certain pixels for more intense events. In March and April 2022 while Solar Orbiter was close to perihelion STIX observed several flares which were strong enough to trigger the first RCR level and insert the attenuator. These events will be examined.

STIX Spectra can also be combined with that of other X-ray instruments - recent work has been done to simultaneously determine the combined spectrum of flares jointly observed by STIX and XSM. XSM is the Solar X-ray Monitor on board the Chandrayaan-2 mission of the Indian Space Research Organisation. As XSM has an overlapping energy sensitivity, measuring X-rays in the range 1- 15 keV, it provides very complementary data providing a more complete understanding of flares including the multi-thermal nature of the hot plasma and the abundances. We will compare the joint results with the individual fits from each instrument.

P110: Fortunato Vito – On advanced data and information visualization for decision support on in situ observations: the ERMES software suite, from SWA and beyond

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The amount of information that can be extracted and derived from scientific data increases dramatically during the advancement of the mission; it becomes evident the need to have advanced visualization and data analysis tools available, in order to provide coordinated decision support able to eventually trace transient events occurring on a short time scale. Initially born as a SW suite of Electrical Ground Support Equipment (EGSE) for AIV of the Data Processing Unit of the Solar Wind Analyzer, it has then evolved into an element for verifying the performance of the application and scientific SW in a completely web-based environment, now it is ripe to become a point coordinated data analysis of (inter-) instrument, so as to exploit the capabilities of its high-performance time-series backed database component as well as the frontend HMI for analytics and interactive visualization web application providing charts, graphs and alerts.

P111: Tomasz Mrozek – Plasma dynamics in solar flare footpoints observed by STIX

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Solar flares are efficient accelerators of energetic particles, mainly electrons, which transport energy from reconnection site to chromosphere. Energetic electrons are thermalized in the chromosphere via Coulomb collisions with chromospheric plasma. During that process HXRs are emitted (bremsstrahlung). The approximation of the HXR emission mechanism , known as the thick-target model, is well developed. It predicts that in flare foot points, we should observe lowering of HXR sources' altitude with increasing energy. It was registered for group of flares observed by past HXR telescopes like Yohkoh/HXT and RHESSI. The energy-altitude relation was found to be very efficient method for analysing the energy deposition process, properties of non-thermal electron beam and the plasma dynamics in flare footpoints. The Spectrometer/Telescope for Imaging X-rays (STIX) is a new HXR experiment which was launched onboard the Solar Orbiter mission. Since January 2021, STIX has already observed thousands of solar flares. We selected a group of strong (>M1.0 GOES class) events and investigated it for existence of the energy-altitude relation in flare footpoints. Here we present the results of time evolution of the relation that was registered in HXR images reconstructed from STIX data. In our analysis we also used images from Full Sun Imager (FSI) of the Extreme Ultraviolet Imager (EUI) in 174 and 304 Å, and from AIA telescopes on board Solar Dynamics Observatory (SDO) to verify the geometry of the events. The density changes within chromospheric region were found which we used for conducting plasma parameters (mass) changes within footpoint area. Due to high time resolution STIX allowed us to trace changes of energy-altitude relation with great details, observed never before.

P112: Chris Nelson – Evolution of burst events in the transition region and corona

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Burst-like events are observed across a vast range of temperatures in the solar atmosphere, from Ellerman bombs in the photosphere to campfires in the corona. It has been widely hypothesised that the majority of these features are driven by dynamic magnetic reconnection, with the properties of the reconnection (e.g., height, energy) determining the spectral properties of the observed bursts. In the first half of this talk, we present new results obtained for UV bursts, a transition region phenomenon which occur predominantly in active regions, obtained through analysis of data from the Interface Region Imaging Spectrograph (IRIS). Specifically, we examine whether the properties (frequency, area, spectra, locations of occurrence) of these events vary or are consistent through time in seven evolving active regions. This research allows us to gain an understanding of where and when magnetic energy is dissipated through magnetic reconnection in active regions during their lifetimes. It is found that most properties remain relatively consistent with time, with only the spatial areas containing bursts appearing to become larger as active regions age. In the second half of this talk, we present some initial results from analysis of co-spatial IRIS and Solar Orbiter datasets. We examine whether there is a spectral response in spectra sensitive to the transition region (e.g. Si IV, O IV) co-spatial to campfires in Extreme-Ultraviolet Imager data.

P113: Jean-Baptiste Dakeyo – Radial iso-poly solar wind model constrained by Parker Solar Probe, Solar Orbiter and Helios measurements between 0.1 and 1 au

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Classifying solar wind observations by HELIOS in several populations sorted by bulk speed, has revealed constant and slight accelerations of the wind as it expands away from the Sun in the 0.3 – 1 au radial range. The faster the wind is, the smaller is this acceleration. Recent measurements from Parker Solar Probe (PSP) and Solar Orbiter, which have been added closer to the Sun, show that the HELIOS populations can nicely be extrapolated back to the Sun. For instance the well established bulk speed/proton temperature (u, Tp) correlation, together with the acceleration of the slowest winds, are clearly visible in the PSP and Solar Orbiter data.

Based on the previous classifications, we present results of empirical Parker-like models for which the solar wind undergoes a double expansion: isothermal in the corona, then polytropic after the sonic point, with polytropic indices corresponding to the observed temperature gradients. Such models are useful because they allow to establish a differentiated energy balance for the heating of the wind and for the acceleration separately.

P114: Hardi Peter – Wide stable loops in the corona and other diffuse features

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Loops in the corona of the Sun come in a variety of temperatures, lengths and lifetimes. Active region loops seen in extreme UV emission originating from around 1MK are mostly thought to be seen in a cooling phase after having been heated to significantly higher temperature. In terms of their cross section the majority of these loops are not resolved, i.e. they appear as thin strands or a collection of such thin strands that typically evolve on the cooling time scale of about one hour. Recent observations with the high-resolution telescope of the Extreme Ultraviolet Imager (EUI) onboard Solar Orbiter in the 174 Å channel shows thin strands on the cross-sectional scale comparable to its unprecedented spatial resolution of about 200 km. However, some of the loops seen by EUI also appear thick and remarkably stable in terms of their cross-sectional and temporal evolution. In particular, we report here on a loop that has a full width half maximum of three to four times the spatial resolution of EUI (6 to 8 pixels). This width of the loop is almost constant along the better part of its length and is stable over time. What is remarkable is this high degree of stability of the loop. Observations of increasingly higher resolution as well as modern 3D numerical simulations with high resolution show that the only thing in the corona that is constant is the change. So, the question arises how the Sun produces a structure so stable while most (if not all) modern heating mechanisms naturally lead to significant variability. This paradoxical question can also be applied to other diffuse solar features that often do not get the attention they deserve because our eye is usually drawn to the transient features.

P115: Andreas Debrabandere – Characterization of Solar Wind Ion Composition with SOHO for Comparison with Solar Orbiter Measurements

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The solar wind ion composition can provide information on many levels about the Sun and the heliosphere. In order to compare upcoming solar wind composition measurements from the Solar Orbiter mission to typical elemental and charge state abundances in the heliosphere at 1 AU, we use data from the SOHO/CELIAS/CTOF sensor to derive the relative abundances of more than 20 heavy ion species around solar minimum in 1996. The results are obtained from a statistical analysis based on an improved instrumental response and efficiency model of the CTOF sensor, which has a similar operation principle as the SWA/HIS instrument on Solar Orbiter (SolO). From the future comparison of the SolO/SWA/HIS composition measurements at solar distances down to 0.3 AU with an established baseline at 1 AU, we aim to understand better the origin and evolution of the solar wind. In addition these abundance measurements can help to identify the seed population of suprathermal and energetic particles that are accelerated in solar transients at different distances from the Sun.

P116: Daniel B. Graham – Langmuir waves in type III source regions

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Type III solar radio bursts are produced by very fast electron beams generated near the Sun, and are characterized by radio emissions that rapidly drift from high frequencies to low frequencies as the beams propagate away from the Sun. The fast electron beams generate Langmuir waves, which are subsequently converted to radio waves at the local plasma frequency and the second harmonic. The processes that convert Langmuir waves to electromagnetic radio waves are not fully understood. Suggested processes include three-wave interactions, linear mode conversion, antenna mechanisms, modulational instabilities, and wave packet collapse. Here we investigate which Langmuir wave processes are occurring in type III source regions using waveform data captured by Solar Orbiter. We investigate how the Langmuir wave processes depend on heliospheric distance. We also compare the Solar Orbiter results with the results from past missions, such as Wind and STEREO, at 1 AU.

P117: Miho Janvier – The 3D standard model of eruptive solar flares put to test during the Solar Orbiter first active region observation campaign

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Eruptive solar flares are amongst the most energetic events in our solar system. Accompanied by intense UV and X-ray emissions, they can inject energetic particles into the interplanetary medium and are accompanied by coronal mass ejections (CMEs). All these various aspects can have a large impact on solar system bodies in general, and more specifically can have a detrimental effect on human activities. Thus, there is a strong interest to gain a deeper knowledge of the underlying processes leading to these solar eruptions.

Over the past decades, ground and space solar observatories and the variety of observations available (from imaging to plasma and particle diagnostics and magnetic field measurements) have helped us refine a standard model for eruptive flares. Over the years, such a model was extended to its 3D version, explaining generic features such as: flare ribbons, evolution of flare loops, the underlying reconnection processes leading to the emission of particles and an erupting magnetic structure.

During the first remote-sensing observation campaign of its nominal mission (March – April 2022), Solar Orbiter has provided an unprecedented close view of the Sun's atmosphere and has captured an M-class flare and filament eruption on April 2nd 2022 with almost all its instruments. This flare and subsequent eruption were also seen from different positions by a variety of spacecraft, including Solar Dynamics Observatory, Hinode and IRIS.

In the present study, we investigate the evolution of the early phase of the filament eruption, covered at unprecedented high spatial and temporal cadences with EUI/HRIEUV, followed by the eruption itself. The combination of SPICE and EIS spectrometers provides for the first time a stereoscopic view of the plasma flows, along EUI, AIA and STIX for the EUV/X ray imaging. We will show how this remarkable set of stereoscopic observations provides a test to the 3D standard eruptive flare model as the different viewpoints allows us, for the first time ever, to simultaneously probe the different features expected from the model.

P118: Miho Janvier – Solar Orbiter and the solar/heliospheric fleet coordinated observations of a filament eruption: a test bed for a global eruptive flare model

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Eruptive solar events can lead to the formation and the expulsion of large-scale magnetic structures in the interplanetary medium, called coronal mass ejections (CMEs), as well as, the acceleration and injection of particles within the heliosphere. CMEs transport solar plasma and magnetic field in the solar system; along with high energy particles, they can interact with the space environment of planets. It is critical to improve our understanding of how these drivers of space weather evolve, from their initiation at the Sun's outer atmosphere, the corona, to their propagation in the interplanetary space. However, while CMEs and high energy particles are routinely measured remotely and in situ by spacecraft dedicated to observe the Sun and the solar wind, so far our measurements have been restricted to few positions close to 1 au and near the ecliptic.

In the first remote-sensing campaign of its nominal phase, Solar Orbiter and the heliophysics fleet of other solar missions (SDO, SoHO, Hinode, IRIS and STEREO-A) were ideally placed to observe simultaneously, and from different vantage points, eruptive solar events occurring on April 2nd 2022 and its accompanying CME detected in situ a few hours later. In this presentation, we will review first the unprecedented wealth of data covering the pre-eruption phase, to the eruption and early coronal propagation, the high energy particles and plasma waves detections and, finally, the in situ measurements of the CME detected directly by Solar Orbiter. We will then focus on the solar wind connectivity and CME/shock propagation to understand the timings, features and the widespread nature of high energy particles and plasma waves detected by several spacecraft.

By providing simultaneous observations at different positions in the inner solar system, Solar Orbiter and the other spacecraft can now help us integrate models of eruptive flares and CMEs and energetic particles into one global solar eruption model linking the Sun's atmosphere to the inner heliosphere. The April 2nd 2022 eruptive event also provides a great example of the capabilities of joint observation campaigns and what is next for the future observation windows of the Solar Orbiter nominal mission.

P119: Krishnendu Mandal – Hemispheric asymmetry of solar differential rotation inferred by time-distance helioseismology

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Solar differential rotation is well characterized from global helioseismology method which analyzes splitting of acoustic mode frequencies. One of the limitation of above analysis is that only north-south symmetric component of the rotation can be determined in this way. Observation shows that solar activity is not symmetric in both hemispheres. As we know from dynamo theory that differential rotation and solar activity are interconnected. Therefore it is important to determine north-south asymmetric component of the rotation in order to understand what drives the hemispheric asymmetric nature of solar activity. As this could be a crucial input for solar dynamo theory,

We use time-distance helioseismology to answer the above question. We analyze 11 years of Doppler velocity data from GONG and SDO/HMI. We first determine hemispheric symmetric component of the rotation and compare it with the results from global helioseismology. We find a very good agreement between global and time-distance helioseismology. We also find torsional oscillation in our results. After validating our analysis we determine north-south asymmetric component of the rotation. We find that rotation in south hemisphere is stronger than that in north hemisphere. This asymmetry is small close to the equator but it gets stronger at higher latitude. This is observed in both the data sets from GONG and SDO/HMI. We are investigating the implication of this findings.

As GONG and SDO/HMI does not have enough coverage close to the polar region of the Sun, it is difficult to constrain differential rotation close to the pole. Solar orbiter can help us in constraining that as it will be observing the polar region of the Sun.

P120: Argyrios Koumtzis – A new code for nonlinear force-free magnetic field extrapolation in the solar corona implemented on a Yin Yang grid

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The solar magnetic field dominates and structures the coronal plasma and detailed insights are important to understand almost all physical processes. While direct routine measurements of the coronal magnetic field are not available, we have to extrapolate the photospheric vector field measurements into the corona. To do so, we developed a new code that performs state-of-the-art nonlinear force-free magnetic field extrapolations in spherical geometry. Our new implementation is based on an optimization principle and is able to reconstruct the magnetic field in the entire corona, including the polar regions. Because of the nature of the finite-difference numerical scheme used in the past, extrapolation close to polar regions was computationally inefficient. In the current code, the so-called Yin Yang grid is used. Both the speed and accuracy of the code is improved compared to previous implementations. We tested our new code with a well known semi-analytical model (Low and Lou solution). This new Yin and Yang implementation is timely because the Solar Orbiter mission is expected to provide reliable vector magnetograms also in the polar regions within the following years. Thus, this code can be used in the future when these synoptic magnetograms are available to model the magnetic field of the solar corona for the entire Sun including the polar regions.

P121: G. Nicolini – Metis imaging of coronal “fireworks”

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Images acquired during a Metis IT-8 commissioning activity, have revealed multiple tiny coronal-jet-like structures, named “fireworks”, outwardly propagating along the boundaries between adjacent flow tubes. We'll discuss possible interpretations of these structures including also comet fragmentation, Kelvin-Helmholtz-related vortices or coronal-jet-producing erupting-mini-filament flux ropes.

P122: Tatiana Niembro – Following a prominence eruption from the Sun to Parker Solar Probe with multi-spacecraft observations

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In the early hours of 2021 April 25, the Solar Probe Cup on-board Parker Solar Probe (PSP) registered the passage of a solar wind structure characterized by a clear and constant He+2/proton density ratio above 6% during three hours. The alpha contribution remained present but faint and intermittent within a twelve-hour window. Solar Orbiter (SolO) and PSP were in nearly perfect quadrature, allowing for an optimal observing configuration in which the material impacting PSP was in the SolO plane of sky and visible off the limb. In this work, we report the helium-enriched plasma structure from the Sun to PSP combining multi-spacecraft remote sensing and in situ measurements. We identify an erupting prominence as the likely source, behind the Sun relative to the Earth, but visible to multiple instruments on both the Solar-Terrestrial Relations Observatory-A (STA) and SolO. The associated CME was also observed by coronagraphs and heliospheric imagers from both spacecraft before reaching PSP at 46 Rs, 8 hours after the spacecraft registered a crossing of the heliospheric current sheet. Except for the extraordinary alpha ratio enhancement, the CME showed ordinary plasma signatures and a complex magnetic field with an overall enhancement. The PSP/WISPR images show a structure entering the field of view a few hours before the in situ crossing followed by repetitive transient structures that may be the result of flying through the CME body. We believe this to be the first example of a CME being imaged by PSP/WISPR directly before and during being detected in situ. This study highlights the potential of combining PSP in situ measurements in the inner heliosphere with simultaneous remote-sensing observations in (near) quadrature from other spacecraft.

P123: Petr Heinzel – Metis visible-light observations of eruptive prominences and CME cores

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Metis coronagraph on board the Solar Orbiter has the capability to detect visible-light (VL) linear polarization in the 580-640 nm wavelength bandpass. The HeI D3 587.6 nm line is included in this range. In eruptive prominences and CME cores, the VL emission is normally caused by the Thomson scattering on electrons and the linear polarization degree Q/I is expected to be high, reaching 90%. However, as shown in Heinzel et al. (2020), the presence of the HeI D3 587.6 nm line inside the Metis VL channel can lead to substantial modification (lowering) of Q/I due to D3 emission from a cool plasma. In such situation, also U/I can be non-zero due to the magnetic field (Hanle effect). We will present first Metis observations of VL polarization in eruptive structures and will discuss them in terms of possible influence of cool plasmas emitting the D3 line.

P124: Monica Laurenza – Transient and recurrent cosmic ray variations observed by Solar Orbiter

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The intensity of galactic cosmic rays (GCRs) at a given heliospheric location is modulated by solar wind perturbations. For example, interplanetary coronal mass ejections (ICMEs) may cause transient GCR intensity depressions known as Forbush decreases whose morphological aspects at different locations are related to the spatial and temporal evolution of the ICMEs. Moreover, the passage of corotating high-speed solar wind streams may also produce GCR variations which can recur for more than one solar rotation, as well as crossings of the heliospheric current sheet. In general, such GCR variations are produced by the strong or turbulent magnetic field structures associated with magnetic perturbations that may act as barriers in the GCR transport. In this work we analyse transient and recurrent GCR decreases observed by EPD onboard Solar Orbiter during the period April 2020 – February 2022 in the inner heliosphere. We also investigate their association with interplanetary structures, in order to obtain new insights in understanding the interaction between high-energy particles and solar wind disturbances, focusing on the role of the magnetic field configuration, drifts and diffusion in modulating the energetic particle intensity.

P125: Jenny Marcela Rodriguez Gomez – Plasma Properties of Quiet Sun Small-Scale Solar Dynamic Features in the Transition Region and Upper Chromosphere

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Small-scale solar dynamic features have been observed by Solar Orbiter EUI and SPICE (Berghmans et al. 2021; Panesar et al. 2021; Fludra et al. 2021). We are interested in the small-scale features in the Quiet Sun network observed in EUV by Spectral Imaging of Coronal Environment (SPICE; SPICE Consortium et al. 2020). Time series of Ne VIII 770 Å, CIII 977 Å, OVI 1032 Å, and Lyman-β 1026 Å were used to analyze these features through the transition region and upper chromosphere. These time series were observed in the wide slit (30″) movies and narrow slit (2″, 4″ and 6″) spectrum. We used the line ratio method and the Differential Emission Measure (DEM) to obtain the plasma properties of Quiet sun small-scale dynamic features.

P126: Samuel Gissot – Performance of the Extreme Ultraviolet Imager (EUI) High-Resolution EUV Imager (HRI-EUV) telescope: from pre-flight calibration to first in-flight images

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The High-Resolution Extreme Ultraviolet imager (HRI-EUV) is the EUV telescope with high spatial resolution of the EUI instrument. It is based on an off-axis Cassegrain design optimized to observe the solar corona at a wavelength of 17.4 nm.

Following the calibration campaigns of its optical components, i.e., the entrance and focal aluminium foil filters, multilayer coated mirrors, and CMOS APS detector, an end-to-end EUV radiometric calibration of the HRI-EUV telescope was performed in April 2017 using the synchrotron radiation of the Metrology Light Source (MLS) electron storage ring of the Physikalisch-Technische Bundesanstalt (PTB) in Berlin.

We report the results of the HRI-EUV optical components and instrument calibration campaigns, from which we derive the instrument performance parameters.

We will also report in-flight performance as assessed during the commissioning calibration operations, including acquisitions in dark conditions and using the internal LED calibration source, as well as the analysis of EUV images acquired since May 12th, 2020.

P127: Alejandro Moreno Vacas – Preliminary results of the cross-calibration between the Full Disk Telescope of the Polarimetric Helioseismic Imager onboard Solar Orbiter and the Helioseismic and Magnetic Imager onboard Solar Dynamics Observatory

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We present preliminary results of the cross-calibration of data acquired with the Full Disk Telescope (FDT) of the Polarimetric and Helioseismic Imager (SO/PHI) on board of the Solar Orbiter (SolO) spacecraft with the data of the Helioseismic and Magnetic Imager (HMI) onboard the Solar Dynamics Observatory. For the cross-calibration, magnetic field data obtained during the first SolO Remote Sensing Window, while SolO was crossing the Sun-Earth line is used. We have performed a pixel-to-pixel comparison of, preliminary, the longitudinal component of the magnetic field vector for both instruments. The method of pixel selection is based on the World Coordinate System implemented in both SO/PHI-FDT and HMI metadata. In first order we find a good correlation between the line of sight magnetic field of SO/PHI and HMI. In second order there are non-negligible differences due to the different spatial resolutions of the two instruments and data processing to which the data is subjected to before the inference of the magnetic field vector.

P128: Hamish Reid – Microwaves and Type III Bursts Associated Temporally and Spatially in the Upper Corona

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During solar energy release events, some accelerated electrons can travel downwards into the dense chromosphere whilst others are able to escape into the upper solar corona and beyond. Typically these electron populations are studied in isolation and so our understanding of how the upper and lower solar atmosphere is linked during acceleration events remains limited. Insufficient focussing to this problem has partially been related to the lack of simultaneous imaging spectroscopy available at microwaves (GHz) and metre waves (MHz) frequencies, released via either gyrosyncrotron or plasma emission. We combine interferometric imaging from the LOw Frequency ARray (LOFAR) and the Siberian Radioheliograph (SRH) of a solar radio noise storm that occurred during the 2nd PSP perihelion. We find a temporal correlation between the GHz and MHz emission on longer timescales, indicating the acceleration region has magnetic connectivity to both the lower and upper solar corona. We show how the time delay between the emission can be used to estimate the density stratification in the solar corona. We argue that a source of emitting electrons is located near the compact sunspot where foot points of two loop systems with very different sizes are close together.

P129: Daniel Ryan – Deriving and Visualising 3-D Properties of thermal X-ray sources in Solar Flares Using SolO/STIX, Hinode/XRT and JHelioviewer

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The 3-D locations and volumes of hot plasmas (>5MK) are crucial to understanding the evolution of solar flares. However to date, such observations have only ever been made in 2-D. Estimating source volumes from these measurements has relied on approximate area-to-volume scaling laws while estimating source locations has relied on making assumptions about the sources' place within the magnetic field structure inferred from 2-D EUV images. In this presentation we outline the challenges and achievements of an effort to directly infer the locations and volumes of hot flare plasma by leveraging the substantially different viewing angles offered by two X-ray imagers, SolO/STIX and Hinode/XRT. In addition we have developed new tools to import 3-D geometric structures into JHelioviewer and used them to compare our derived structures with the imaging observations in the JHelioviewer database. Deriving and visualizing the 3-D properties of hot flare plasma using such techniques promise to improve our understanding of numerous aspects of solar flare evolution including energetics, cooling mechanisms, and the spatial relationship between the hottest plasmas and magnetically connected structures such as ribbons and footpoints.

P130: Nils Janitzek – Looking for signatures of reaccelerated flare particles in gradual SEP events measured with Solar Orbiter

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Flare-associated particles might be efficiently reaccelerated in gradual Solar Energetic Particle (SEP) events. The existence and characteristics of such a flare-associated seed population might play a key role for understanding the high variability in particle fluxes under comparable CME speeds and solar wind conditions. We investigate systematically a number of CME-associated gradual events between fall 2020 and spring 2022 that show ion composition compatible with a contribution from flare-associated impulsive eruptions and ion velocity dispersion that hints towards observed flares and/or active regions on the Sun. To identify whether energetic particles have been reaccelerated at the CME shock front before reaching the Solar Orbiter spacecraft, we study in detail the evolution of suprathermal and energetic particle intensities during the event, investigate the ion energy spectra, and try to relate these quantities to the observed CME properties under the ambient solar wind conditions.

P131: Mihir Desai – Suprathermal Ion Observations Associated with the Heliospheric Current Sheet Crossings by Parker Solar Probe During Encounters 7-11

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We report observations of <100 keV/nucleon suprathermal (ST) H, He, O, and Fe ions in association with three separate crossings of the heliospheric current sheet that occurred near perhelia during PSP encounters 7, 8, and 9. In particular, we compare and contrast the ST ion time-intensity profiles, velocity dispersion, pitch-angle distributions, spectral forms, and maximum energies during the three HCS crossings. We find that these unique ST observations are remarkably different in each case, with those during E07 posing the most serious challenges for existing models of ST ion production in the inner heliosphere. In contrast, the ISOIS observations during E08 appear to be consistent with a scenario in which ST ions escape out of the reconnection exhausts into the separatrix layers after getting accelerated up to ~50-100 keV/nucleon by HCS-associated magnetic reconnection-driven processes. Finally, ST ions during the E09 HCS crossing have properties that are somewhat similar to those seen during both E07 and E08 crossings, with ion intensities being higher outside the exhausts and the separatrices, but significant intensity increases are also observed inside the reconnection exhausts. We discuss these new observations in terms of local versus remote acceleration sources as well as in terms of expectations of existing ST ion production and propagation, including reconnection-driven and diffusive acceleration in the inner heliosphere.

P132: B. L. Alterman – Heavy Ion Heating Observed by Solar Orbiter HIS Across a Shock

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Ion mass-per-charge and shock geometry determine the number of times a charged particle is reflected across a shock. As such, they govern charged particle acceleration at shocks. Solar Orbiter's Heavy Ion Sensor (HIS) measures solar wind heavy ion velocity distribution functions (VDFs) at a 30 cadence. Combined with magnetic field observations, we can extract 3D He^{++} and $O6^{+}$ VDFs, characterizing their temperatures perpendicular and parallel to the local magnetic field. We then report on the preferential heating and acceleration mechanisms based on the reflected/heated ion anisotropy from these VDFs depending on shock obliquity.

P133: Giuseppe Nisticò – Investigating the density fine structuring of the solar corona with Comet Lovejoy

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The low-beta and optically thin plasma in the solar corona is structured in the form of thin flux tubes elongated along the local magnetic field. Such fine structuring is not always evident in EUV and coronagraphic observations until the application of image filtering, due to the integration along the line-of-sight of the radiation that progressively smooths out the intensity gradients of the local density inhomogeneities.

The density structuring of the solar corona was also revealed by Comet C/2011 W3 (Lovejoy), which transited through the solar corona in December 2011. The tail of Comet Lovejoy, as observed in EUV with the Atmospheric Imaging Assembly (AIA) of the Solar Dynamics Observatory (SDO), appeared in the form of thin striations or "striae", made visible by the emission of cometary oxygen ions injected along the local coronal magnetic field lines.

We present a study of the spatial and time evolution of these striae as observed in the channel at 171 Å of SDO/AIA. The scenario that we propose considers a stria as a beam of oxygen ions injected along the local magnetic field and subject to two effects: a velocity decrease because of collisions with the local plasma and spreading because of collisional diffusion. The characteristic times of both the processes, i.e., the collision time for the slowing down of the beam and the diffusion time, depend on the ambient plasma density. We developed a model where the beam position in time is determined by these processes and the associated synthetic density profiles of the ion density along the magnetic field are computed and conveniently compared with the 171 Å intensity profiles along the striae to constrain the values of the local plasma density.

We show that the density fine structures highlighted by the comet have a common nature with those measured in the solar corona during eclipses and coronagraphic observations, such as those obtained from Solar Orbiter/METIS.

P134: Xingyao Chen – Radio source positions from the spectral observations by Parker Solar Probe, Solar Orbiter, STEREO, and Wind

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We investigate the directivity and source positions from the type III burst simultaneously observed by Parker Solar Probe, Solar Orbiter, STEREO, and Wind. The source positions are determined and compared from the intensity fits and the triangulation method. The directivity from observations suggests the radio waves propagate with anisotropic scattering effects by comparison with the directivity of solar radio emissions using ray-tracing method to simulate the radio-wave propagations and considering the Parker spiral model of interplanetary magnetic field.

P135: Liang Zhao – Depletion of Heavy Ion Abundances in Slow Solar Wind and its Association with Quiet Sun Regions

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The exact coronal origin of the slow-speed solar wind has been under debate for decades in the Heliophysics community. Besides the solar wind speed, the heavy ion composition, including the elemental abundances and charge state ratios, are widely used as diagnostic tool to investigate the coronal origins of the slow wind, because the freeze-in process makes the wind's composition do not change after it is accelerated from the base of the corona. In this study, we recognize a subset of slow speed solar wind that is located on the upper boundary of the scattered plot in the 2D O7+/O6+ versus C6+/C5+ frame (O-C plot). In addition, in these wind, the heavy ion abundances over the density of proton, such as N/P, O/P, Ne/P, Mg/P, Si/P, S/P, Fe/P, He/P, and C/P are systemically depleted. We compare these winds ("upper depleted wind" or UDW hereafter) with the slow wind that are located in the main stream of the O-C plot and possess comparable Carbon abundance range as the depletion wind ("normal-depletion-wind", or NDW hereafter). We find that the proton density in the UDW is lower than in the NDW by about 27%. Charge state ratio of C6+/C5+, C6+/P, C5+/P, O7+/O6+,O7+/P, and O6+/P are also decreased by 16.8%, 17.8%, 14.5%, 64.4%, 61.7%, and 6.3%, respectively. The occurrence rate of these UDW is anti-correlated with solar cycle: more in solar minimum and less in solar maximum. By tracing the wind along PFSS field lines back to the Sun, we realize that the coronal origins of the UDW are more likely associated with quiet Sun regions, while the NDW are mainly associated with active regions and quiet Sun.

P136: Jan Soucek – Polarization of Langmuir waves in the source region of a Type III radio burst

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We analyze in detail a remarkable Type III burst event, when the Radio and Plasma Waves instrument on Solar Orbiter sampled the source region of the radio burst for almost 2 hours. The instrument triggered its burst mode and collected an extensive dataset of Langmuir wave snapshots. The observed waves exhibit complex modulation and varying polarization which develops over the course of the event. We investigated the correlation between the polarization and amplitude of Langmuir waves and the simultaneously observed beam of energetic electrons. We show that the intense transverse waves are associated with a faster electron beam and the polarization becomes more linear as the energy of electrons decreases due to velocity dispersion of the beam.

P137: Shahin Jafarzadeh – Wave propagation in the lower solar atmosphere from SO/PHI and EUI observations

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We make use of seeing-free observations from the Polarimetric and Helioseismic Imager (PHI) as well as the Extreme Ultraviolet Imager (EUI) on board the Solar Orbiter spacecraft to study wave propagations in a sunspot's atmosphere. Oscillations in various photospheric physical parameters, namely temperature, line-of-sight velocity, and magnetic field (obtained from Stokes inversions) as well as those in intensity images are investigated. Propagation of magneto-acoustic waves through the photosphere and chromosphere are then characterised using phase studies between the oscillations identified at various atmospheric heights sampled by the PHI and EUI observations at different wavelengths. The results from this study shall provide new insights to better understand magnetohydrodynamic wave heating of the solar atmosphere in a greater detail.

P138: Regina Aznar Cuadrado – The Pre-flight Calibration of the HRILYA telescope of EUI on-board Solar Orbiter

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The high-resolution telescope HRILYA of EUI is made for imaging at the Lyman-alpha line of hydrogen. It is constructed of a two-mirror Gregorian telescope with two interference filters at the wavelength of 121.7 nm and a camera using a multichannel plate (MPC) intensifier for high spectral purity around 121.7 nm.

Before the launch of Solar Orbiter, together with the two other EUI channels, the HRILYA telescope was calibrated on 20th and 21st April 2017 at the Metrology Light Source (MLS) of PTB in Berlin, where the EUI instrument was placed in a dedicated vacuum tank connected to the MLS beamline. All optical components and the camera had been beforehand calibrated individually by measurements at the MLS on 20th and 21st September 2016.

Here we report the results of the component spectral radiometric response calibrations and show how these correspond to the instrument performance before flight. We also provide the gain calibration of the Lyman-alpha camera as function of MCP voltage, which allows comparing results obtained with different MCP voltages. The overall spectral radiometric response of the Lyman-alpha Channel optical system is a result of the combination of the spectral reflectance of the two mirrors, the transmission of the Entrance filter and the narrow-band Focal Plane filter, and the spectral sensitivity of the detector. The spectral behaviour at wavelengths above 160 nm of the responsivity of the Ly-a Channel camera is dominated by the intensifier and the KBr coating of the MCP.

There are two on-board UV-LEDs that can be used individually for illumination of the detector at a wavelength of 245 nm. The UV-LEDs can be used for tracking of the Lyman-alpha camera response alone at any time of the mission and so, checking its state of health.

P139: Alexandrova Olga – Merging of MAG and RPW/SCM magnetic waveforms on Solar Orbiter: preliminary results

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We study a fast solar wind stream observed on 3 of April 2022 using Solar Orbiter/RPW, MAG and SWA instruments. We combine MAG and RPW/SCM waveforms to cover magnetic field from DC to few hundreds Hz.

This allows us to study magnetic turbulence in the solar wind from MHD to kinetic plasma scales including ion and electron scales. Preliminary results on spectral properties and intermittency will be shown.

P140: Luca Teriaca – Calibrating the VUV instruments of Solar Orbiter with stars: first results from the EUI and SPICE observations

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Stars with known and stable vacuum ultraviolet spectral irradiances can be used to verify and monitor the radiometric calibration of instruments operating in space. In particular, stars from early spectral types are the best candidates for calibration and characterization of instruments operating above 92 nm (below which radiation is absorbed by interstellar hydrogen).

Since the beginning of the cruise phase, Solar Orbiter has made dedicated observing campaigns where the spacecraft points to the solar limb to allow some of the high-resolution instruments to observe the ingress and/or the egress of the target star occultation by the solar disk. The stars are chosen because their luminosity and early spectral type ensure high and stable flux at wavelengths between 100 nm and 122 nm, a range observed by the High Resolution EUI Lyman-α telescope (HRILYA) and by the long wavelength (LW) channel of the SPICE spectrometer.

At the time of writing, three such campaigns have been conducted targeting α Leo on June 16th 2020, θ Oph on March 27th 2021 and ω Sco on June 12th 2022.

We took images and spectra of each of these stars to determine the radiometric response of the instruments by comparing the observed counts to measured reference fluxes and to measure the instruments' spatial point spread function (PSF) by measuring the spatial profile of the image produced by the star.

For SPICE-LW we obtained a first assessment of the radiometric calibration factor and an estimate of the width of the spatial PSF. For HRILYA it has been so far not possible to detect the stars which helps providing a lower limit to its spatial PSF.

These campaigns are the first of several that will be carried-out during the Solar Orbiter mission phases.

P141: Luca Teriaca – The radiometric response and performance evolution of the HRILYA telescope of EUI from first light to now

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HRILYA is the intensified high-resolution telescope of the EUI instrument operating at the Lyman alpha line of Hydrogen. The telescope obtained the first light images on April 12th 2020 and, since then, has acquired images of the solar surface on about 80 different days until June 2022 (last analysed data).

Some of these observations were obtained specifically to calibrate the instrument response to different settings of the high voltages and of the CMOS/APS sensor of the camera and integrate the available measurements taken on the ground. This pre-calibration step is essential in comparing data taken with different setups.

By considering only data taken near disk centre, using the full available field of view, binning not greater than 2×2 and exposure times and high voltage settings suitable for scientific observation, we built a dataset of more than 15000 images. These images were carefully analysed to retrieve information on the average signal and contrast as a function of time and distance between the spacecraft and the Sun.

These results show the evolution of the instrument throughput and (part of) performance through the first two years of life.

Throughput and contrast appear to reduce over the considered period, with the situation worsening significantly during March 2022 apparently in correspondence with the first perihelion (below 0.35 AU).

Besides solar images, UV LED that illuminate it directly (without making use of the optical elements) can also stimulate the camera.

We also analyse LED images taken at the beginning of the mission and compare them to a set acquired recently (June 12th 2022) to try to understand whether the problem concerns the camera or the optical elements. This latter analysis is subject to the availability of the recent data and whose downlink time is expected to be of several weeks.

P142: Lorenzo Matteini – Spherical polarisation and constant magnetic field intensity of Alfvénic fluctuations in the solar wind

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Low-frequency large-amplitude Alfvén waves in the solar wind constitute an important energy source for wind acceleration, heating of the plasma and driving of the turbulent cascade. One of the most striking properties of Alfvénic fluctuations observed in situ and confirmed further by Solar Orbiter measurements closer to the Sun, is that despite large amplitude (dB~B_0) they induce only small changes in the total magnetic field intensity. This state corresponds to a spherical polarisation of the fluctuations, a property which is a non-linear equilibrium solution of ideal MHD, but whose origin and evolution are still not understood.

To explore the onset of spherically polarised Alfvénic fluctuations and of the constant B regime, we perform numerical simulations of the expanding solar wind using a hybrid code (kinetic ions and fluid electrons). We find that a spherical polarisation spontaneously emerges in system from the initial turbulent-like background and is then amplified by expansion. Moreover, when reaching dB/B~1, this dynamics leads also to the generation of localised rapid magnetic field reversals, consistent with magnetic switchbacks observed in situ. The plasma evolves with distance maintaining locally an almost constant magnetic field intensity and the consequent radial scaling of the magnetic fluctuations seen in the simulations is in good agreement with observations. This suggests that - despite a simplified model - our system captures some of the main ingredients of solar wind plasma dynamics associated to the evolution of large-scale Alfvénic fluctuations.

Finally, we discuss how the trend and scaling observed in the simulations can help us to extrapolate the origin of the constant B condition and of the spherical polarisation in the Corona.

P143: Joseph Plowman – Correction of SPICE Doppler Artifacts

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We report on work to correct Doppler artifacts in SPICE spectra. These artifacts are caused by rotation of the spatio-spectral (y-lambda) PSF away from alignment with the y and lambda axes. We show that this rotated PSF can be removed and replaced with a symmetric one using constrained and regularized chi squared fitting along with a model of the spatio-spectral PSF and detector response function effects (e.g., pixelization). We also show SPICE Doppler images before and after correction of the artifacts.

P144: Joseph Plowman – Application of the CROBAR 3D Coronal Reconstruction Method to SPICE Data

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We report on application of the newly developed Coronal Reconstruction Onto B-Aligned Regions (CROBAR) method to Solar Orbited SPICE data. CROBAR leverages the topological constraints in the coronal magnetic field and the requirement for plasma to follow the coronal magnetic field in its reconstructions. As a result, it can usable 3D models of both coronal field and coronal plasma, even with a single snapshot and point of view. We apply this to a active region observed by SPICE and combine it with abundance information to infer the connection of the region to in situ observations made by Solar Orbiter.

P145: Joseph Plowman – A new method for simultaneous determination of SPICE abundances and DEMs

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The spectral lines observed by solar orbiter SPICE are deliberately chosen to have varying sensitivity to the First Ionization Potential (FIP) effect and therefore the abundances (and intensities) vary significantly depending on whether they are emitting from coronal or photospheric environs. This is choice is what allows SPICE to measure remote sensing abundances, but these line intensities also depend on the differential emission measure (DEM -- essentially the mix of emitting temperatures) of the plasma being observed. Previously, this interdependence has been solved by either computing abundances with lines that have the same sensitivity to DEM or by first computing a DEM with subset of lines that all have the same sensitivity to abundance. We demonstrate a new method which requires neither of these and instead finds the best-fit DEM and abundance simultaneously, which can be significantly more flexible than either of the other approaches. We follow this up with testing of the accuracy of the approaches and the trade-offs between them.

P146: David Pisa – Ion-acoustic waves observed under variable solar wind conditions by the Solar Orbiter

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Ion-acoustic waves are common emissions observed in the solar wind along the Solar Orbiter's orbit. These oscillations are generated via ion-ion or current-driven instabilities below the local proton plasma frequency. However, due to the substantial Doppler shift, they are typically observed in the frequency range between the local electron and proton plasma frequency in the spacecraft frame. Ion-acoustic waves often accompany large-scale solar wind structures and may play a role in ion diffusion due to wave-particle interactions. Time Domain Sampler (TDS) receiver, a part of the Radio and Plasma Waves (RPW) instrument, is sampling wave emissions at frequencies below 100 kHz almost continuously from the beginning of the mission. Thus nearly two years of observations allow us to perform a statistical study of ion-acoustic waves in the solar wind covering an interval of heliocentric distances between 0.5 AU to 1 AU and variable conditions in the solar wind. The occurrence of low-frequency waves increases with decreasing distances from the Sun, with only a few waves detected per day at ~1 AU. The emission is more likely to be observed when the plasma parameters (e. g., proton density and temperature variations) are highly perturbed. A detailed analysis of the Doppler-shift using solar wind data from a Proton and Alpha particle Sensor (PAS) of the Solar Wind Analyzer (SWA) is done for several examples.

P147: Eduard Kontar – Solar corona and the solar wind are turbulent environment with varying properties.

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Using ground-based and space-based observation radio observations of solar radio bursts, we deduce the variation of the level and anisotropy of density turbulence from the Sun to the Earth. The combination of ground and spaced-based observations allow to deduce density turbulence properties from 1.1 R_sun to 1 AU and compare with in-situ density turbulence measurements. The observations suggest that the anisotropy of density turbulence weakly decreases from the Sun to 1 AU, while the deduced density turbulence level allows to explain time, locations and size characteristics of solar radio sources observed by Solar Orbiter/RPW and PSP.

P148: Shaheda Begum Shaik – The SoloHI Observations on SEP producing CMEs: Flare-CME-SEP Connection

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The role of particle acceleration from flares and coronal mass ejections (CMEs) on the origin of SEP (solar energetic particles) seed particles and the connection between flares-CMEs and SEPs are still unclear. We present the preliminary analysis from an initial set of the SEP-producing CMEs observed on 10 March and 30 March 2022 by the Solar Orbiter Heliospheric Imager (SoloHI) onboard the Solar Orbiter mission.

Some CME events do not produce SEPs even though they generate a shock, and some large reconnection events that lack shock waves have flares but do not produce SEPs, showing event-to-event variation. Recent observations from radio instruments like Expanded Owens Valley Solar Array (EOVSA) have shown a new perspective of the standard flare model, having a flaring region with a large spatial scale of low-frequency microwave emission. These flares have shown that the accelerated particles can be transported to a much larger volume than observed at other high-energy wavelengths. When flares and CMEs generate such a large spatial extent of accelerated particles, do they have any unexplored contribution to create the seed particles? If yes, how can event-to-event variations explain the SEP conditions?

To answer these questions, heliospheric imaging from SoloHI can provide crucial information on the accelerated particles that can be smeared during the transport to the distant 1 AU in-situ observations. SoloHI imaging can resolve CME-associated shocks and probe the regions crucial for understanding the connection to the heliospheric and coronal magnetic field configurations. We study the correlation interplay between event parameters and verify the SEP conditions from joint observations of the Solar Orbiter, Parker Solar Probe (PSP; WISPR-FIELDS-IS$\odot$IS), EOVSA, STEREO, and SOHO. This study will address the respective contributions of seed populations from the flare magnetic reconnection and CME-associated shock accelerations.

P149: T. Nieves-Chinchilla – Exploring ICMEs in the inner heliosphere using Solar Orbiter and PSP in situ observations

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Interplanetary coronal mass ejections (ICMEs) carry away a larger amount of magnetic energy, flux, and helicity than any other transient heliospheric structure from the Sun. The most common magnetic configuration to describe the internal structure of the ICMEs is a flux-rope. The smooth rotation in the magnetic field direction observed by in-situ magnetometers can be fitted by models/techniques, allowing the 3D reconstructions and providing physical quantities.

Inner heliospheric observations of ICMEs by Solar Orbiter and Parker Solar Probe at different heliosphere distances will allow researchers to investigate the evolutional processes associated with the propagation in the heliosphere as well as the impact and changes in the internal magnetic structure.

In this contribution we examine and classify the magnetic field signatures of the ICMEs observed by both spacecraft. We then reconstruct the flux rope assuming axial symmetry and extrapolate the physical quantities to understand the role of these large scale structures in the solar wind and the connection with their origin back in the Sun.

P150: Timothy J. Stubbs – SWA-HIS Observations of Ion Species during the Encounter with the Tail of Comet Leonard

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Around 17 December 2021, the Solar Orbiter spacecraft was predicted to have had its closest approach to comet C/2021 A1 (Leonard) with a minimum streamline distance < 0.01 AU. This encounter provided an unprecedented opportunity to investigate in situ comet Leonard's interaction with the solar wind and the composition of pick-up ions produced by ionization and dissociation of outgassed neutrals from its coma. It was a long-period comet originating from the Oort Cloud with a nucleus about 1 km in diameter, with ground-based telescope observations after its perihelion pass (at ~0.62 AU on 3 January 2022) indicating that it had subsequently disintegrated. Prior to perihelion, outbursts had been reported as well as variations in brightness, which had resulted in speculation about an impending disintegration. However, the dimming in November 2021, before the Solar Orbiter encounter, was argued to be due to a transition from outgassing dominated by carbon dioxide to water. Comet Leonard was the brightest comet of the year and noted for its spectacular ion tail with complex structures, including knots and streamers. Preliminary analysis of in situ Solar Orbiter observations have revealed tell-tale signatures of a cometary encounter around the time of predicted closest approach, such as evidence for magnetic field line draping. However, the clearest evidence has come from Solar Wind Analyzer-Heavy Ion Sensor (SWA-HIS) observations of singly-charged oxygen ions, which are not of solar origin and can only be produced when the solar wind interacts with a comet or other Solar System body. In this presentation we use SWA-HIS data to investigate aspects of the solar wind interaction and composition of cometary pick-up ions from this active, long-period comet shortly before its disintegration.

P151: R. Kieokaew – Solar Orbiter observations of the Kelvin-Helmholtz waves in the solar wind

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The Kelvin-Helmholtz (KH) instability is a nonlinear shear-driven instability that develops at the interface between shear flows in plasmas. KH waves have been inferred in various astrophysical plasmas, and have been observed in situ at the magnetospheric boundaries of solar-system planets and through remote sensing at the boundaries of coronal mass ejections. KH waves are also expected to develop at flow shear interfaces in the solar wind. While they were hypothesized to play an important role in the mixing of plasmas and in triggering solar wind fluctuations, their direct and unambiguous observation in the solar wind was still lacking. In this poster, I will present in situ observations of quasi-periodic magnetic and velocity field variations plausibly associated with KH waves in the slow solar wind adjacent to the heliospheric current sheet using Solar Orbiter during its cruise phase. Their evidence including analyses of the shear layer stability, local boundary configuration, as well as the MHD simulation using estimated empirical conditions will be presented. Finally, I will discuss reasons for the lack of observations and, in particular, the implication and importance of KH development in the driving of solar wind fluctuations as typically observed at 1 AU.

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P152: Chadi Salem – Radial Evolution and Kinetics of Ion Species with Helios

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Despite being measured over 40 years ago, the Helios data still provide a fantastic opportunity to study the solar wind. For ion studies, previous work has mainly focused on moments of the three-dimensional distribution functions or fits to the proton core and alpha-particle populations. However, moments do not offer the resolution needed for many investigations and proton beam populations, which can be significant, are not captured by the existing fitting methods. Here we adapt recently developed code to include the proton beam as a third fitted population. With three populations, the ion distribution functions can often be well characterised, supporting more in-depth kinetic studies. We present statistics of the proton beam and alpha-particle populations in various solar wind streams, focusing on parameters such as drift speeds and temperature anisotropies. We also investigate the radial evolution of each ion population.