EP 4: Sun and Heliosphere II

Time: Tuesday 13:45–15:45 Location: ZHG101

Invited Talk EP 4.1 Tue 13:45 ZHG101

The Solar Orbiter Mission and the Polarimetric and Helioseismic Imager instrument: new opportunities for novel science — •Gherardo Valori — Max Planck Institute for Solar System Research (MPS), Göttingen, Germany

Solar Orbiter is a joint ESA-NASA mission that was launched in 2020 on a strongly eccentric orbit around the Sun, with closest perihelia at 0.28 AU. The Polarimetric and Helioseismic Imager is the vector magnetohraph onboard Solar Orbiter (SO/PHI), and it is composed of the Full-Disc Telescope (FDT) images the entire solar disk, while the High-Resolution Telescope (HRT) observes a smaller part of the solar disk at high resolution.

With an orbit of about six months around the Sun, SO/PHI is the first magnetograpgh providing maps of the photospheric vector magnetic field from viewpoints away from the Sun-Earth line, including from the far side of the Sun. This opens new science opportunities and novel boundary conditions for data-driven and data-inspired numerical simulations, such as following active regions for much longer periods of time, faster synoptic maps, and the stereoscopic resolution of the 180-degree ambiguity.

Starting from spring 2025, SO started to raise significantly above the ecliptic, providing full spectropolarimetric observations of the solar poles for the first time, which will be crucial for the quantitative constraint of the magnetic field in heliospheric models. Finally, SO/PHI is also the forerunner of the Photospheric Magnetic-field Imager (PMI) onboard the forthcoming L5 mission Vigil.

EP 4.2 Tue 14:15 ZHG101

The inferred active region magnetic field at different vantage points: an analysis with SO/PHI and SDO/HMI — •Jonas Sinjan[1], Johann Hirzberger[1], Daniele Calchetti[1], Sami K. Solanki[1], Gherardo Valori[1], Xiahong Li[1], David Orozco Suárez[2], Julián Blanco Rodríguez[3], and Hanna Strecker[2] — [1]Max-Planck-Institut für Sonnensystemforschung, Göttingen, Deutschland — [2]Instituto de Astrofísica de Andalucía, Granada, Spain — [3]Universitat de València, Parterna-Valencia, Spain

The open flux problem is currently an unsolved mystery, representing a 2-3 factor mismatch between the open flux measured at 1 AU and that via remote sensing of the solar atmosphere and extrapolated to 1 AU. One explanation is that the open flux at the photosphere is underestimated, in particular in the polar regions. Until now it was impossible to test this with observations: Solar Orbiter (SO), with its on board magnetograph (the Polarimetric and Helioseismic Imager, PHI) has made this a reality such that the photospheric magnetic field can be observed simultaneously from two different vantage points.

First the impact of the viewing angle on the inferred magnetic field, open or closed, can be evaluated. From 12 - 17th October 2023 Solar Orbiter observed an active region (NOAA 13465) together with SDO/HMI, with an angular separation of 60-80 degrees. This dataset allows for the μ-correction (which assumes the field to be radial) to be observationally tested for the first time. A comparison will be shown of the evolution and magnitude of the magnetic field inferred by SO/PHI-HRT with that from SDO/HMI at these different vantage points.

EP 4.3 Tue 14:30 ZHG101

Stereoscopic disambiguation of solar vector magnetic fields using observations from SO/PHI and SDO/HMI — •Xiang Li, Gherardo Valori, Daniele Calchetti, Sami Solanki, Johann Hirzberger, and Jonas Sinjan — Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany

The solar vector magnetic field is inferred from spectropolarimetric observations of the polarization in magnetically sensitive spectral lines. However, the transverse component has a 180° ambiguity in its orientation. Traditional single-view methods for resolving the ambiguity require assumptions on the properties of the photospheric magnetic field. The Polarimetric and Helioseismic Imager (PHI) on board Solar Orbiter (SO) makes it possible to remove the ambiguity purely using observations from two vantage points. The Stereoscopic Disambiguation Method (SDM), which was developed based on this idea, has been successfully tested on simulated data and first science data acquired from the High Resolution Telescope (SO/PHI-HRT) in spring 2022. In this work, we applied the SDM to a number of SO/PHI-HRT datasets and corresponding datasets from the Helioseismic and Magnetic Imager (HMI) on board Solar Dynamics Observatory (SDO). The SDM successfully disambiguates the vector magnetograms in strong field areas, and for a large range of separation angles between the viewpoints. We analyzed quantitative diagnostic metrics on different observational configurations to explore factors that may affect the reliability of the SDM in localized areas. Furthermore, a possible improvement of SDM is proposed based on a detailed analysis of the SDM equations.

EP 4.4 Tue 14:45 ZHG101

First results on coronal magnetic field modelling with Solar Orbiter data — •Thomas Wiegelmann, Xiaohong Li, Sami K. Solanki, and Gherardo Valori — MPI for Solar System Research, Göttingen, Germany

Understanding the coronal magnetic field is crucial for studying almost all solar physical processes. To do so we extrapolate the measured photospheric magnetic field vector into the solar corona and beyond. For large-scale modeling, we use a stationary MHD approach to reconstruct the global coronal and interplanetary magnetic field up to approximately ten solar radii. In the inner corona, below about 2.5 solar radii, where solar wind flow and plasma forces are negligible, we apply a nonlinear force-free field model. In the thin layer between the photosphere and the corona, where plasma forces become significant, a magnetohydrostatic model is employed. We present initial results demonstrating how vector magnetograms from the Polarimetric and Helioseismic Imager (PHI) aboard Solar Orbiter can enhance coronal magnetic field models and deepen our understanding of the Sun. Key contributions from Solar Orbiter include high-resolution magnetic field measurements and unique observations of polar regions. Finally, we discuss how these new data sets can be combined with global coronal magnetic field models based on observations from the Solar Dynamics Observatory (SDO).

EP 4.5 Tue 15:00 ZHG101

Unveiling the dynamics and thermal structures of the jet base from SO high-resolution observation — •Xiaohong Li — Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany

Solar jets, characterized by small-scale plasma ejections along open magnetic field lines or the limbs of large-scale coronal loops, play a crucial role in the dynamics of the solar atmosphere. Solar Orbiter (SO) enables us to investigate the structure of solar jets with much higher spatial and temporal resolutions and from different angles. Using the EUI/HRI data, we observed firework-like structures, which are the dynamic manifestations of the jet base. This bright structure is located above the magnetic neutral line, the region where reconnection occurs. Numerous flows spread out from the reconnection point to the surrounding area at speeds exceeding 100 km/s. By analyzing the evolution of the magnetograms from PHI/HRT, we identified a clear flux cancellation process at the footpoint of the jet. Testing different extrapolation methods, including potential field, nonlinear force-free field, and magnetohydrostatic field, we find the jets display fan-spine structures. The base flows are confined within the fan structure, with the highest flow speed near the null point. Additionally, the temperature peaks near the null-point, proving that persistent magnetic reconnection drives the recurrent jets. These high-resolution observations provide new insights into the complex dynamics and thermal structures at the base of solar jets, advancing our understanding of their formation and contribution to solar atmospheric phenomena.

EP 4.6 Tue 15:15 ZHG101

Diffraction limited solar spectro-polarimetry and first steps towards solar many-line inversion — •J. Hölken[1], H.-P. Doerr[1,2], A. Feller[1], M. van Noort[1], T. L. Riethmüller[1], S. K. Solanki[1,3], W. Cao[4,5], J. Kang[6], J. Chae[6], and E.-K. Lim[7] — [1]Max-Planck-Institut für Sonnensystemforschung, Germany — [2]Thüringer Landessternwarte, Germany — [3]School of Space Research, Kyung Hee University, Republic of Korea — [4]Big Bear Solar Observatory, USA — [5]New Jersey Institute of Technology, USA — [6]Astronomy Program, Seoul National University, Republic of Korea — [7]Korea Astronomy and Space Science Institute, Republic of Korea

In this contribution we present the first diffraction limited spectropolarimetric data from a 1.6 meter telescope with unprecedented spatial and outstanding spectral resolution.

To explore the performance of image restoration of high resolution solar spectra we extended the FISS instrument installed at the Goode Solar Telescope (GST) by spectro-polarimetric capabilities, a fast context imager, and a large format spectrograph camera. The resulting instrument can accommodate a spectral range in excess of 30 Å. This allows for the simultaneous full Stokes observation of more than 160 solar absorption lines.

In contrast to stellar physics, for solar spectra the simultaneous observation and interpretation of only a few lines is still typical. Here, we combine for the first time the information of more than 80 lines. In comparison to results from a line-doublet inversion, we find more fine-structure and better constrained values.

EP 4.7 Tue 15:30 ZHG101

Probing chromospheric fine structures with an Hα proxy using MURaM — •Sanghita Chandra[1], Robert Cameron[1], Damien Przybylski[1], Sami Solanki[1], Patrick Ondratschek[1], and Sanja Danilovic[2] — [1]Max Planck Institute for Solar System Research, Justus von Liebig Weg, 37077 Göttingen, Germany — [2]Institute for Solar Physics, Dept. of Astronomy, Stockholm University, Albanova University Center, 10691 Stockholm, Sweden

The solar chromosphere is composed of dynamic fine structures that remain poorly understood. Using the MURaM-ChE code, which incorporates NLTE physics for chromospheric modeling, we simulate an enhanced network element. The results reveal finely structured features resembling rapid red and blue-shifted excursions (RREs and RBEs) in the Hα wings and dynamic fibrils in the line core. We devise a proxy for the Hα spectral line that identifies similar features rooted in network patches, that may play a critical role in supplying mass and energy to the solar corona. One such feature, an RBE with a Doppler shift of 37 km/s, forms through flux emergence and reconnection events, with Lorentz forces expanding the field and driving a jet-like flow. This feature originates in the mid chromosphere (2-4 Mm above the surface), has a lifetime of 246 seconds, reaches 3.4 Mm in length, and exhibits lateral motion. Strong viscous and resistive heating at its onset propagates a heating front at Alfvenic speeds.