Extraterrestial Physics Division
Fachverband Extraterrestrische Physik (EP)

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Overview of Invited Talks and Sessions

(Lecture halls ZHG101 and ZHG005; Poster ZHG Foyer 1. OG)

Plenary Talk of EP

PV I	Mon	11:30–12:15	ZHG011	**The solar magnetic field and variability** — •Sami K. Solanki

Invited Talks

EP 1.1	Mon	16:45–17:15	ZHG005	**The new planet formation theory** — •Joanna Drazkowska
EP 2.1	Mon	16:45–17:15	ZHG101	**Sunrise III 2024: Flight and first scientific results** — •Andreas Korpi-Lagg, H.N. Smitha, Sami K. Solanki, Achim Gandorfer, Alex Feller, Tino Rierthmüller, Pietro Bernasconi, Thomas Berkefeld, Jose Carlos del Toro Iniesta, Yukio Katsukawa, Sunrise III Team
EP 3.1	Tue	13:45–14:15	ZHG005	**Atmospheric modelling from ground to lower thermosphere** — •Claudia Stephan
EP 3.4	Tue	14:45–15:15	ZHG005	**Beauty and hazards created by the terrestrial magnetosphere** — •Elena Kronberg
EP 4.1	Tue	13:45–14:15	ZHG101	**The Solar Orbiter Mission and the Polarimetric and Helioseismic Imager instrument: new opportunities for novel science** — •Gherardo Valori
EP 5.3	Tue	16:45–17:15	ZHG005	**Heliosphere as a natural laboratory of turbulence and plasma nonlinearities** — •Yasuhito Narita
EP 6.1	Tue	16:15–16:45	ZHG101	**Decoding coronal loops: Structure and dynamics** — •Sudip Mandal
EP 9.1	Wed	16:15–16:45	ZHG005	**A JWST View of Exoplanet Atmospheres: Everything We Dreamed Of, and More** — •Laura Kreidberg
EP 12.1	Thu	16:15–16:45	ZHG101	**The Influence of Intermittent Turbulence on Solar Energetic Particle Transport: Modelling and Observations** — •Frederic Effenberger
EP 13.1	Fri	9:00– 9:30	ZHG101	**High-Mass X-Ray Binaries: Living Together with a Black Hole** — •Lidia Oskinova
EP 15.1	Fri	13:30–14:00	ZHG101	**Nucleosynthesis of heavy elements in the hot and dense plasmas of explosive astrophysical environments** — •Daniel Siegel

Invited Talks of the joint Symposium SMuK Dissertation Prize 2025 (SYMD)

See SYMD for the full program of the symposium.

SYMD 1.1	Mon	14:15–14:45	ZHG011	**Fluid-dynamic description of heavy-quark diffusion in the quark-gluon plasma** — •Federica Capellino
SYMD 1.2	Mon	14:45–15:15	ZHG011	**Fast and faithful effective-one-body models for gravitational waves from generic compact binaries** — •Rossella Gamba
SYMD 1.3	Mon	15:15–15:45	ZHG011	**Nuclear Structure Near Doubly Magic Nuclei** — •Lukas Nies
SYMD 1.4	Mon	15:45–16:15	ZHG011	**Optimisation strategies for proton acceleration from thin foils with petawatt ultrashort pulse lasers** — •Tim Ziegler

Invited Talks of the joint Symposium Turbulence in Space and Fusion Plasmas (SYSF)

See SYSF for the full program of the symposium.

SYSF 1.1	Wed	13:45–14:15	ZHG101	**Addressing turbulence questions in the Wendelstein 7-X stellarator device - a combined experimental and theoretical approach** — •Josefine Proll, Paul Mulholland, MJ Pueschel, Maikel Morren, Gavin Weir, Ksenia Aleynikova, Adrian von Stechow, Pavlos Xanthopoulos, Gabriel Plunk, the W7-X Team
SYSF 1.2	Wed	14:15–14:45	ZHG101	**Particle acceleration and transport in astrophysical, magnetized turbulent plasmas** — •Martin Lemoine
SYSF 1.3	Wed	14:45–15:15	ZHG101	**Turbulence in the young solar wind, results from Solar Orbiter and Parker Solar Probe** — •Robert Wicks, Utsav Panchal, Julia Stawarz, Stefan Lotz, Du Toit Strauss, Amore Nel
SYSF 1.4	Wed	15:15–15:45	ZHG101	**Digital Solutions for EUROfusion** — •Volker Naulin

Sessions

EP 1.1–1.4	Mon	16:45–18:10	ZHG005	**Planets and Small Bodies I**
EP 2.1–2.5	Mon	16:45–18:15	ZHG101	**Sun and Heliosphere I**
EP 3.1–3.6	Tue	13:45–15:45	ZHG005	**Near-Earth Space I**
EP 4.1–4.7	Tue	13:45–15:45	ZHG101	**Sun and Heliosphere II**
EP 5.1–5.6	Tue	16:15–18:15	ZHG005	**Near-Earth Space I & Planets and Small Bodies II**
EP 6.1–6.7	Tue	16:15–18:15	ZHG101	**Sun and Heliosphere III**
EP 7.1–7.4	Wed	11:00–12:05	ZHG005	**Planets and Small Bodies III**
EP 8	Wed	12:15–13:30	ZHG101	**Members' Assembly**
EP 9.1–9.7	Wed	16:15–18:15	ZHG005	**Exoplanets and Astrobiology**
EP 10.1–10.22	Thu	11:00–12:30	ZHG Foyer 1. OG	**Poster Session**
EP 11.1–11.8	Thu	13:45–15:45	ZHG101	**Sun and Heliosphere IV**
EP 12.1–12.6	Thu	16:15–18:00	ZHG101	**Sun and Heliosphere V**
EP 13.1–13.5	Fri	9:00–10:30	ZHG101	**Astrophysics I**
EP 14.1–14.6	Fri	11:00–12:30	ZHG101	**Astrophysics II**
EP 15.1–15.9	Fri	13:30–16:00	ZHG101	**Astrophysics III**

Members' Assembly of the Extraterrestial Physics Division

Wed 12:15–13:30 ZHG101

EP 1: Planets and Small Bodies I

Time: Monday 16:45–18:10 Location: ZHG005

Invited Talk EP 1.1 Mon 16:45 ZHG005

The new planet formation theory — •Joanna Drazkowska — Max Planck Institute for Solar System Research, Göttingen, Germany

The classical theory of planet formation originated when our knowledge about planets was limited to the Solar System alone. The numerous discoveries of exoplanet systems have compelled a revision of this theory, aided by cutting-edge observations of circumstellar disks and precise laboratory studies of Solar System materials. Nonetheless, the formation of planets remains one of the major unsolved problems in modern astrophysics. In this talk, I will outline the emerging paradigm in which centimeter-sized dust aggregates, colloquially known as pebbles, take center stage. Focusing on the early stages of planet formation, we will examine the growth process of tiny dust grains into pebbles, as well as the formation of planetesimals, the first gravitationally-bound building blocks that precede today's asteroids and comets. Finally, I will present the latest results of numerical models revealing a likely scenario of the formation of massive planet chains.

EP 1.2 Mon 17:15 ZHG005

First results of JUICE-SWI from the Lunar Earth Gravity Assist maneuver — •Paul Hartogh, Christopher Jarchow, Ladislav Rezac, and Miriam Rengel — Max-Planck-Institut für Sonnensystemforschung, Göttingen

The Submillimetre Wave Instrument (SWI) is part of JUICE (JUpiter ICy moons Explorer). JUICE is the first Large Class mission (L1) of the ESA's Cosmic Vision programme. SWI will investigate the stratosphere of Jupiter (general circulation, chemistry, isotopic composition) and the atmospheres and surfaces of the Galilean satellites (dynamic and kinetics, molecular and isotopic composition, composition of volcanic and potential cryovolcanic plumes) in the far infrared in two submillimeter wave bands (500 and 250 micrometers). In August 2024 the JUICE spacecraft passed Earth and Moon during the LEGA (Lunar Earth Gravity Assist). During the lunar gravity assist SWI observed the rotational ground states of water vapor (ortho- and para water) in nadir mode. During the Earth flyby, numerous observation modes were executed, observing the Earth atmosphere in nadir and limb modes. Of particular interest are the 250 micrometers results, because the Earth was observed for the first time from space with high resolution techniques in this range of the electromagnetic spectrum. This talk will present the first results of the LEGA data analysis and illustrate the power of submillimeter wave observations in investigating physical processes.

EP 1.3 Mon 17:30 ZHG005

TRIPLE-IceCraft - a Melting Probe for the Exploration of Subglacial Lakes in Antarctica in Preparation for the Icy Moons — •Dirk Heinen[1], Jan Audehm[1], Clemens Espe[2], Mia Giang Do[1], Marco Feldmann[2], Gero Francke[2], Fabian Schöttler[2], Christopher Wiebusch[1], and Simon Zierke[1] — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]GSI - Gesellschaft für Systementwicklung und Instrumentierung mbH, Aachen, Germany

The TRIPLE project, initiated by the German Space Agency at DLR, is researching Technologies for Rapid Ice Penetration and subglacial Lake Exploration. TRIPLE aims to explore the subglacial ocean of Jupiter's moon Europa. The mission will be preceded by a technology demonstration in Antarctica. To access the subglacial water reservoir, a drill or melting probe must first penetrate the ice. The TRIPLE-IceCraft melting probe is a modular payload carrier system designed to transport arbitary scientific payloads through the ice. The design is capable of traversing several hundred metres of ice, penetrating into a subglacial ocean or lake, and later returning to the surface. The TRIPLE-IceCraft has been tested in an analogue scenario on the Ekström Ice Shelf in Antarctica in 2023 and 2024. In this talk we present the TRIPLE-IceCraft design and the results of the test campaigns.

EP 1.4 Mon 17:45 ZHG005

A MEMS-based Miniaturized Fabry-Perot Spectrometer for Lunar Exploration — •Matthias Grott[1], Jörg Knollenberg[1], Lynn Miller[1], Christian Althaus[1], Toni Grossmann[2], Julia Wecker[2], Jörg Martin[2], Andreas Ihring[3], Boris Jung[1], and Konstantinos Vasiliou[1] — [1]German Aerospace Center, Institute of Planetary Research, Berlin, Germany — [2]Fraunhofer Institute for Electronic Nano Systems, Chemnitz, Germany — [3]Leibniz Institute of Photonic Technology, Jena, Germany

Rock forming minerals as well as organic compounds show distinct spectral features in the mid and long infrared wavelength range that can be used to characterize materials in-situ. We have developed a spectrometer prototype based on a micro-electromechanical system (MEMS) Fabry-Perot filter using thermopile detectors that covers the 8 to 11 μm wavelength range. The mass of the instrument's sensor head is expected to be less than 100 g and the total electronics mass is estimated to be 100 g without housing, making the instrument suitable for applications on small landed exploration platforms and CubeSats. The instrument design and results from the initial instrument characterization will be presented.

Poster pitch: EP 10.13 (Becker), EP 10.14 (Schmit)

EP 2: Sun and Heliosphere I

Time: Monday 16:45–18:15 Location: ZHG101

Invited Talk EP 2.1 Mon 16:45 ZHG101

Sunrise III 2024: Flight and first scientific results — •Andreas Korpi-Lagg[1], H.N. Smitha[1], Sami K. Solanki[1], Achim Gandorfer[1], Alex Feller[1], Tino Rierthmüller[1], Pietro Bernasconi[2], Thomas Berkefeld[3], Jose Carlos del Toro Iniesta[4], Yukio Katsukawa[5], and Sunrise III Team[1,2,3,4,5] — [1]MPS, Göttingen — [2]JHUAPL, Laurel, USA — [3]KIS, Freiburg, Germany — [4]IAA, Granada, Spain — [5]NAOJ, Tokyo, Japan

Sunrise III completed a highly successful science flight in July 2024 on a stratospheric balloon. The seeing-free observing conditions and the high optical quality of the telescope combined with the superb pointing and image stabilization system delivered diffraction-limited images to the three science instruments, spanning a wavelength range from the near-ultraviolet (SUSI, 309-417 nm), over the visible (TuMag, 517-525 nm), to the near infrared (SCIP, 765-855 nm). The flight was controlled from the Göttingen Operations Center at MPS.

The high activity level of the Sun allowed Sunrise III to observe a wide variety of solar features: Maps and sit-and-stare scans of quiet-sun and plage regions, sunspots, pole and limb from the two spectropolarimeters and the imaging spectropolarimeter allow seamless determination of the atmospheric conditions including the magnetic field vector with an unprecedented combination of spatial resolution and height coverage, from the deep photosphere to the upper chromosphere.

I present a summary of the flight, and an overview of the Sunrise III observations with a few early highlights from all three science instruments.

EP 2.2 Mon 17:15 ZHG101

Solar small-scale magnetic elements in the ultraviolet — •Ajay Kumar Yadav[1], Natalie Krivova[1], Tino Riethmüller[1], Smitha Narayanamurthy[1], Sami Solanki[1], Durgesh Tripathi[2], Anamparambu Ramaprakash[2], Andreas Korpi Lagg[1], Alex Feller[1], and Achim Gandorfer[1] — [1]Max Planck Institute for Solar System Research, Göttingen, Germany — [2]Inter-University Centre for Astronomy and Astrophysics, Pune, India

Solar UV irradiance is crucial for the chemistry and ozone balance in the terrestrial atmosphere and, thus, its variations could influence the climate. Existing models attributing irradiance vari- ability to solar surface magnetism have been very successful in reproducing the total and some of the spectral irradiance measurements. However, significant discrepancies between various data and models persist in the range 200*400 nm. The brightness contrast of small-scale magnetic features, which strongly depends on the magnetic field strength, their position on the solar disk, and the wavelength, can provide critical constraints and help resolving the existing discrepancy. UV data suitable for such an analysis were not available until recently. This has changed with the launch of the Aditya-L1 mission carrying the Solar Ultraviolet Imaging Telescope (SUIT) and the third flight of the ballon-borne Sunrise-3 telescope. We will present initial results from the analysis of the available images of the Sun at UV wavelengths in the range 200*400 nm

EP 2.3 Mon 17:30 ZHG101

Towards a reconstruction of the annual solar Irradiance over the past 9 millennia — •Duresa Temaj[1], Natalie Krivova[1], Sami Solanki[1], Illya Usoskin[2], and Bernhard Hofer[1] — [1]Max planck institute for solar system research, Goettingen, Germany — [2]Space Climate Research Unit, University of Oulu, Finland

Space-based observations of solar irradiance since the 1970s revealed its variability, but these records are too short to reliably assess solar impact on Earth's climate. Therefore, irradiance reconstructions are needed, which requires proxies of past solar activity. The longest direct proxy is the sunspot number, recorded for the past 400 years. We employ the Spectral And Total Irradiance REconstructions (SATIRE) model, using the sunspot number as input, while also accounting for the emergence of small-scale magnetic features, to reconstruct solar irradiance from direct sunspot observations.

Furthermore, concentrations of cosmogenic isotopes, e.g. 14C and 10Be, in terrestrial archives, allow reconstructions of sunspot numbers over nine millennia, albeit at a decadal resolution, except the last millennium. Thus, solar cycles remain unresolved. Based on previous findings that cycle strength and length correlate well with the mean solar activity, we study the relationships between the decadally averaged sunspot numbers and solar cycle parameters. We validate this approach using synthetic records constructed from telescopic data and find a fair agreement with the observed record. We apply the derived relationships to reconstruct the annual sunspot number and then irradiance over the nine Millennia.

EP 2.4 Mon 17:45 ZHG101

Global inertial oscillations of the sun — •Laurent Gizon — Max-Planck-Institut für Sonnensystemforchung, 37077 Göttingen — Georg-August-Universität Göttingen, Institut für Astrophysik und Geophysik, 37077 Göttingen

Global oscillations of the Sun consist of two known classes: the well-studied 5-minute acoustic oscillations, which are used in helioseismology, and the recently discovered inertial oscillations with periods on the order of the Sun's rotation period (Gizon et al. 2021). All observed inertial modes propagate more slowly than the equatorial rotation rate and, due to latitudinal differential rotation, these modes have critical latitudes where their phase speeds match the local rotation rate. Linear forward modeling indicates that the mode eigenfrequencies and eigenfunctions are highly sensitive to the Sun's internal differential rotation, as well as to poorly understood properties of solar convection zone, such as the superadiabatic temperature gradient. Additionally, nonlinear simulations (Bekki et al. 2024) suggest that the high-latitude modes with the largest amplitudes are baroclinically unstable and play a significant dynamical role in shaping the Sun's internal rotation profile. In this presentation, we will present a progress report on this highly promising new field of solar physics.

EP 2.5 Mon 18:00 ZHG101

Nonlinear saturation mechanism of solar high-latitude inertial modes — •Muneeb Mushtaq, Damien Fournier, and Laurent Gizon — Max-Planck Institute for Solar System Research, Goettingen, Germany

At high latitudes the solar rotation rate drops fast with increasing latitude and is linearly unstable. In this presentation we discuss the nonlinear saturation mechanism, which controls the amplitude of the high-latitude solar inertial modes. Using nonlinear numerical simulations of purely toroidal modes on the sphere, we show that the bifurcation is supercritical.This justifies the use of the weakly nonlinear theory to model the development of the disturbance amplitude and to determine to what value it saturates. We find a simple relationship between the mode amplitude and the linear growth rate of the mode.

EP 3: Near-Earth Space I

Time: Tuesday 13:45–15:45 Location: ZHG005

Invited Talk EP 3.1 Tue 13:45 ZHG005

Atmospheric modelling from ground to lower thermosphere — •Claudia Stephan — Leibniz Institute of Atmospheric Physics at the University of Rostock, Kühlungsborn, Germany

The mesosphere and lower thermosphere (MLT) extend from an altitude of approximately 50 km to a few hundred kilometres. Highly dynamic physical processes in the MLT are driven by solar and magnetospheric forcing from above and by meteorological disturbances from below. The MLT layer is of increasing societal relevance as its weather directly affects the functionality of ground- and space-based communication and navigation systems. In addition, it hosts a growing number of satellites that monitor weather and climate or support critical technologies. Long-term trends in the MLT are mainly driven by increasing concentrations of anthropogenic carbon dioxide (CO2), which is responsible for large negative temperature trends of about -1.6 K/decade in the mesosphere. Atmospheric waves are associated with variability in winds, temperature and pressure on time scales of minutes to days. In particular, gravity waves are essential for coupling all atmospheric layers, from the troposphere to the thermosphere, but are difficult to treat in numerical models. Exascale computing allows global-scale simulations with horizontal grid spacings in the range of 1-10 km. In such models, resolved orography and non-orographic gravity wave sources provide a realistic wave forcing of the overlying atmosphere with explicitly simulated vertical energy and momentum transport. We extend these efforts to the MLT.

EP 3.2 Tue 14:15 ZHG005

A global picture of the ionosphere response to solar wind during equinox — •Claudia Borries — DLR, Institut für Solar-Terrestrische Physik

The ionosphere can change significantly with the solar wind conditions. Especially during storm conditions, e.g. the impact of an interplanetary coronal mass ejections, large deviations from quiet conditions can be observed in different ionospheric observables. Modelling and predictions of ionospheric storm conditions is a great challenge because of the large variability in the storm characteristics and so far, there is no global model, which is capable in reproducing ionosphere storm conditions. In our study, we analyse the Total Electron Content (TEC) with respect to its response to solar wind conditions with the goal to extract general characteristics for different regions, local times and delays to solar wind variability. Statistical analysis is applied on the TEC map data provided by the International GNSS Service for the period 2005-2023. We compare these general characteristics with a recent very strong storm in May 2024 to show, how well they agree with actual storm characteristics.

EP 3.3 Tue 14:30 ZHG005

Atmospheric impact of the extreme geomagnetic storm of May 10/11, 2024 — •Miriam Sinnhuber — Karlsruher Institute of Technology, Karlsruhe, Germany

On May 10-11, two CMEs arriving within few hours initiated a geomagnetic storm with a DST of around -400 nT in the main phase. With a Kp of 9 for several hours, the threshold for an *extreme* geomagnetic storm was reached for the first time since the Halloween storm in October/November 2003, and polar lights were clearly visible well into magnetic midlatitudes. Proton fluxes were enhanced for several days, reinforced by a third CME arriving on May 13; however, they were distinctly lower than for the Halloween SPE of October 2003, making this a fairly moderate solar proton event. Analyses of satellite datasets MLS/AURA and ACE-FTS/SCISAT show a moderate ozone loss in the high-latitude upper mesosphere, as well as increases of NO and N2O in the upper mesosphere at magnetic mid-to high latitudes. The spatial structure of the response is consistent with a moderate solar proton event, but it appears to be weaker than, e.g., the response to the much more moderate geomagnetic storm of April 2010. However, a direct comparison is difficult as the instruments used to assess the

April 2010 or Halloween storms are inoperable now. This emphasizes on the one hand the large spread of possible impacts of geomagnetic storms, on the other hand the need for continuing global observations.

Invited Talk EP 3.4 Tue 14:45 ZHG005
Beauty and hazards created by the terrestrial magnetosphere — •Elena Kronberg — LMU, Munich, Germany

Space weather activity during the current solar cycle maximum draws our attention to striking phenomena, such as auroras seen at unusually low latitudes. It also raises concerns about whether modern technology is sufficiently protected from space hazards. In this talk I will discuss magnetospheric mechanisms that generate auroral features such as spirals. These mechanisms also make powerful particle accelerators. Energetic particles at 100s of keV are responsible for lost observation time in astrophysical X-ray missions such as XMM. They may damage observations from the prospective magnetospheric mission SMILE. Machine learning based models of the charged particle population are derived to mitigate such costly losses. Magnetospheric dynamics also leads to changes in the atmosphere, which in the long term may affect planetary habitability.

EP 3.5 Tue 15:15 ZHG005
Space Weather monitoring and research with new ground-based monitoring capabilities during the maximum of Solar Cycle 25 — •Jens Berdermann, Martin Kriegel, Daniela Banyś, Mainul Hoque, David Wenzel und Dmytro Vasylyev — Deutsches Zentrum für Luft- und Raumfahrt e.V., Kalkhorstweg 53, 17235 Neustrelitz, Germany

By reaching the maximum of solar cycle 25 the influence of space weather is becoming increasingly visible, with phenomena like radio bursts, solar flares and geomagnetic storms occurring more frequently and also with impact on technical systems. Therefore, we have set up a ground-based space weather observation system to continuously monitor the actual space weather situation and related conditions in the upper atmosphere. The system combines a CALLISTO receiver to track solar radio bursts in the frequency range from 10 to 1,600 MHz covering HF, VHF and L-band spectrums, a VLF GIFDS receiver for solar flare detection as well as a high rate GNSS receiver for monitoring ionospheric scintillations. The prototype system is being operated at the Multi-instrument Ionospheric Radio observation Array (MIRA), a measurement field at the DLR site in Neustrelitz, to conduct the final testing and performance analysis. The expansion to other locations in Europe and worldwide in cooperation with partner institutions is intended and it will further increase the coverage. In this presentation, we will show the system's benefits for space weather research and services based on the analysis of the latest events from the maximum of solar cycle 25.

EP 3.6 Tue 15:30 ZHG005
Simulations of the CHerenkov Atmospheric Observation System (CHAOS) — •Pierre Bornfleth, Hannes Ebeling, and Ava Pohley — Christian-Albrechts-Universität zu Kiel

The Earth is continuously exposed to high-energy charged particles, so-called Galactic Cosmic Rays (GCRs). When these particles hit the Earth's atmosphere, they create a cascade of secondary particles. CHAOS uses a new detector design developed at the Department of Extraterrestrial Physics at Kiel University by a team of students to measure the different particle species of the primary GCRs above the so-called Regener-Pfotzer Maximum. To perform these measurements a combination of multiple solid state detectors and a bismuth germanium oxide (BGO) scintillator is used to measure the energy depositions of the particles. The use of an additional Cherenkov aerogel scintillator allows to separate between electrons and protons. Because electrons are much lighter than ions, electrons with energies above ~ 1.1 MeV will trigger the Cherenkov detector whereas ions with the same energy are much slower and will not trigger the Cherenkov detector. CHAOS flew on a stratospheric balloon as part of the BEXUS program in early Oktober 2024. In this talk I present a comparison between simulations of the detector and the measurements of the flight to identify which particles were measured and what energy they had.

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.

EP 5: Near-Earth Space I & Planets and Small Bodies II

Time: Tuesday 16:15–18:15 Location: ZHG005

EP 5.1 Tue 16:15 ZHG005

Preliminary Results of the CHerenkov Atmospheric Observation System (CHAOS) from the 2024 Balloon Experiments for University Students (BEXUS) Campaign — •Hannes Ebeling, Pierre Bornfleth, and Ava Pohley — Christian-Albrechts-Universität zu Kiel

The Earth is continuously exposed to high-energy charged particles, so-called Galactic Cosmic Rays (GCRs). When these particles hit the Earth's atmosphere, they create a cascade of secondary particles. CHAOS uses a new detector design to measure the different particle species of the primary GCRs above the so-called Regener-Pfotzer Maximum. To perform these measurements, a combination of multiple solid state detectors and a bismuth germanium oxide (BGO) scintillator is used to measure the energy depositions of the particles. The use of an additional aerogel Cherenkov scintillator allows to separate between electrons and protons. Because electrons are much lighter than ions, electrons with energies above ~ 1.1 MeV will trigger the Cherenkov detector whereas ions with the same energy are much slower and will not trigger the detector. Developed by a team of students at the Department for Extraterrestrial Physics at Kiel University, CHAOS flew on a stratospheric balloon as part of the BEXUS programme in fall 2024. In this talk I present the preliminary results from CHAOS's balloon flight.

EP 5.2 Tue 16:30 ZHG005

Investigation of the occurrence of significant deviations in the magnetopause location: Solar wind and foreshock effects — •Niklas Grimmich[1], Adrian Pöppelwerth[1], Martin Owain Archer[2], David Gary Sibeck[3], Ferdinand Plaschke[1], Wenli Mo[4], Vicki Toy-Edens[4], Drew Lawson Turner[4], Hyangpyo Kim[5], and Rumi Nakamura[5] — [1]Institut für Geophysik und Extraterrestrische Physik, Technische Universität Braunschweig, Braunschweig, Germany — [2]Department of Physics, Imperial College London, London, UK — [3]NASA Goddard Space Flight Center, Greenbelt, Maryland, USA — [4]Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland, USA — [5]Space Research Institute, Austrian Academy of Sciences, Graz, Austria

Recent studies have shown that some effects of upstream conditions on the location of the magnetopause may still be poorly understood, as deviations between empirical models and in situ observations are quite common. Using data from three multi-spacecraft missions to near-Earth space (Cluster, THEMIS and MMS), we can investigate the occurrence of these magnetopause observations. We test whether the deviant magnetopause crossings are statistically associated with foreshocks and/or different solar wind types, and show that in at least 40% of the cases the foreshock can be responsible for the large deviations in magnetopause position. In addition, two distinct classes of solar wind are found to be more frequently associated with the occurrence of magnetopause deviations: the "fast" solar wind and the solar wind plasma associated with transient events.

Invited Talk EP 5.3 Tue 16:45 ZHG005

Heliosphere as a natural laboratory of turbulence and plasma nonlinearities — •Yasuhito Narita — Institut für Theoretische Physik, Technische Universität Braunschweig, Braunschweig, Germany

Heliosphere is a spatially extended domain of the solar plasma expanding radially away from the Sun with a supersonic speed, and has a length scale of about 100 astronomical units. The heliosphere serves as the largest laboratory of turbulence to us, in which various complex and irregular motions of plasma and magnetic field can be studied in detail using in-situ spacecraft. Understanding the nonlinear processes constituting heliospheric plasma turbulence has immediate implications to various research fields in space and astrophysics: turbulent dynamo mechanism generating a large-scale magnetic field, acceleration and scattering of cosmic rays, and mass and angular momentum transfer problem particularly important in the rotating system like accretion disks. Early spacecraft measurements in 1960s hinted that the heliospheric plasma is apparently in the fully-developed turbulent state, for the energy spectrum of the magnetic field fluctuations is reminiscent of the inertial range of fluid turbulence. While a number of spacecraft observations, theoretical modelings, and numerical simulations successfully contributed to build a rough picture of plasma turbulence in the heliosphere, many questions remain still unanswered. I review recent observational studies of heliospheric turbulence focusing on the inner heliosphere such as Parker Solar Probe, Solar Orbiter, and BepiColombo cruise to Mercury, and also review critically theoretical pictures and concepts.

EP 5.4 Tue 17:15 ZHG005

Kinetic simulations of Helium in the Hermean plasma environment — •Fabio Prencipe[1,2], Markus Fränz[1], Harald Krüger[1,3], Norbert Krupp[1], Daniel Heyner[2], and Ferdinand Plaschke[2] — [1]Max-Planck-Institute for Solar System Research, Göttingen, Germany — [2]Institute of Geophysics and Extraterrestrial Physics, TU Braunschweig, Braunschweig, Germany — [3]Planetary Exploration Research Center, Chiba Institute of Technology, Narashino, Japan

Helium was first detected in the Hermean exosphere by the Mariner 10 spacecraft. Sources of the Hermean helium population include outgassing, capture of solar wind He^{2+}, and interstellar pickup He^{+}. Different processes can lead to a change in ionization of helium, e.g. photoionization by solar radiation. Ionized helium can be convected and lost from the plasma environment because of the interaction of the Hermean magnetic field with the solar wind. The abundances of the different helium species in the different Hermean regions are an indicator of the respective dominant helium sources and losses.

The aim of this study is to model the different species of helium in the Hermean magnetosphere in preparation for the arrival of the ESA spacecraft Bepi Colombo. Simple MHD simulations of Mercury's magnetosphere are combined with kinetic simulations of helium atoms. The kinetic simulations include ionization and loss processes in order to investigate the evolution of the different helium species. A statistical analysis of the helium atoms is used to study the ratios of the helium species in the different regions of the Hermean environment.

EP 5.5 Tue 17:30 ZHG005

Solar wind velocity reconstruction at Mercury using MESSENGER bow shock and magnetopause crossings. — •Daniel Heyner[1], Lars Klingenstein[1], Kristin Pump[1], Sae Aizawa[2], Daniel Schmid[3], and Ferdinand Plaschke[1] — [1]IGEP, TU Braunschweig, Braunschweig, Germany. — [2]LPP, CNRS-Ecole Polytechnique-Sorbonne Université, Paris, France. — [3]IWF, Austrian Academy of Sciences, Graz, Austria

The solar wind plays a critical role in shaping planetary magnetospheres, particularly Mercury's, which is highly sensitive due to its weak intrinsic magnetic field and proximity to the Sun. Solar wind flow speed influences the magnetosphere's aberration angle, tilting it relative to the Mercury-Sun line, and the subsolar standoff distances of both the bow shock and magnetopause.

This study reconstructs solar wind speeds using bow shock and magnetopause crossings observed by MESSENGER's magnetometer. By fitting empirical models to the aberration angle and treating subsolar standoff distances as parameters, we reveal a strong correlation that prevents independent determination of these values. Combining multiple crossings allows us to constrain the aberration angle more effectively. Here, we present the first statistical results, comparing them to average boundary shapes and positions, offering insights into Mercury's magnetospheric dynamics.

EP 5.6 Tue 17:45 ZHG005

Investigation of Mercury's Bow Shock Crossings — •Kristin Pump, Daniel Heyner, and Ferdinand Plaschke — Institut für Geophysik und extraterrestrische Physik, TU Braunschweig

Mercury's intrinsic magnetic field is an obstacle to the supermagnetosonic solar wind and thus a bow shock and magnetopause form. The characteristics of the magnetopause depend on various parameters such as the heliocentric distance (~ pdyn) and the IMF orientation. In theory the bow shock shape and location depend on the Mach number which could not be shown for Mercury's bow shock with in-situ data so far.

In this study we analyze bow shock crossings observed by MESSENGER. From the magnetic shock parameters, we retrieve the Mach number (as a function of plasma beta). This enables new possibilities of evaluating the shape and location of Mercury's bow shock under different upstream conditions. We demonstrate our analysis by showing some specific cases and provide a statistical overview. We compare our findings to heliospheric MHD simulations and Parker Solar Probe measurements. The discovered relationship between the bow shock position and solar wind conditions can enhance our comprehension of the highly dynamic processes in Mercury's space environment.

Poster pitch: EP 10.10 (Bender), EP 10.11 (Pöppelwerth), EP 10.12 (Kleimann)

EP 6: Sun and Heliosphere III

Time: Tuesday 16:15–18:15 Location: ZHG101

Invited Talk EP 6.1 Tue 16:15 ZHG101

Decoding coronal loops: Structure and dynamics — •Sudip Mandal — Max Planck Institute for Solar System Research, Göttingen, Germany

Coronal loops, distinguished by their bright, curved, tube-like appearance, are among the most recognizable features of the solar corona. These loops are fundamental building blocks of the solar corona, making it essential to understand their properties in order to unravel the dynamics of the upper solar atmosphere. Despite several years of research, some of the key fundamental properties of these structures remain a mystery. For example, are these loops truly tube-like or sheet-like structures? If they are tube-like, are their cross-sections circular or elliptical? How do loops maintain their shape over several pressure scale heights, contrary to theoretical predictions? In this talk, I will provide key insights into these questions within the context of ESA's Solar Orbiter mission. Additionally, I will discuss the dynamics of these structures, particularly how coronal loops act as excellent waveguides that allow magnetohydrodynamic (MHD) waves to propagate and dissipate their energy at coronal heights, thereby contributing to the ongoing effort to solve the long-standing coronal heating problem.

EP 6.2 Tue 16:45 ZHG101

Robust yet rare coronal loops observed by EUI on board solar orbiter — •Vasantharaju Naganna and Hardi Peter — Max Planck Institute for Solar System Research, Göttingen, Germany

Coronal loops are the most common intensity features in the coronal filtergrams. However, their true nature and morphology are still debatable. By studying variations of cross-sectional properties along the loop and in time, we can understand the structure and heating of these loops. In this study, we investigated the cross-sectional intensity profiles, both spatially and temporally, of two unique coronal loops, observed in the periphery of two distinct active regions by the Extreme Ultraviolet Imager (EUI) on board Solar Orbiter. The main results of this study are 1. The lifetimes of these two loops (L1 > 120 min & L2 > 45 min) are longer than the typical coronal cooling timescales. 2. The loops exhibited an almost constant width, both spatially and temporally (width for L1 about 2.1 Mm, and for L2 about 1.3 Mm), indicating that the loops are stable cylindrical structures. 3. The loop widths are greater than 6-8 pixels of EUI, indicating that the loop cross-section is uniformly filled on well-resolvable scales. 4. We present observational evidence that the loops are not braided, which strongly suggests that the non-expanding nature of these loops with height cannot be attributed to the twist of the magnetic field lines. We conclude that these coronal loops are steady cylindrical structures of uniform cross section that exist for an unusually long time in the corona, which raises questions on which processes ensure the remarkable stability of these loops and our understanding of the coronal magnetic field structure.

EP 6.3 Tue 17:00 ZHG101

Rapid Coronal Variability — •Abhas Pradhan[1], Lakshmi Pradeep Chitta[1], and Hardi Peter[1,2] — [1]Max Planck Institute for Solar System Research, Goettingen, Germany — [2]Institut für Sonnenphysik (KIS) , Freiburg , Germany

Solar coronal loops are heated to temperatures exceeding 1 MK, despite the photosphere being only ∼5700K. The mechanisms sustaining such extreme temperatures in the corona remain unclear. One hypothesis is that nanoflares, small-scale transient magnetic reconnection events, heat the corona. These nanoflares are thought to create rapid UV/EUV variability at the footpoints of coronal loops. High-resolution observations are required to quantify this variability, which in turn will inform us the occurence and energy contribution of nanoflares to coronal heating. Solar Orbiter's EUI offers higher-resolution coronal observations over several hours, complemented by PHI magnetograms providing photospheric magnetic field data at matching resolution. We analyzed high-resolution EUI 174 Å images (180km/pixel, 5s cadence) of an active region core, along with bright points and the diffuse corona, to detect these rapidly varying events. We find frequent occurrences of such rapid events in moss regions and bright points, typically every 3 to 5 minutes, while diffuse regions show almost no rapid activity. The lifetimes and wait-times of rapid events in bright points and moss show similar patterns, remaining consistent despite changes in the underlying magnetic topology. Our study offers better insights to constrain nanoflare-based heating models and processes responsible for mass and energy injection into the hot loops.

EP 6.4 Tue 17:15 ZHG101

1D hydrodynamics simulations of impulsively heated short loops to explain the origin of EUV brightenings in the quiet Sun. — •Antoine Dolliou[1,2], James Klimchuk[3], Susanna Parenti[2], and Karine Bocchialini[2] — [1]Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany — [2]Université Paris-Saclay, CNRS, Institut d'Astrophysique Spatiale, 91405 Orsay, France — [3]NASA Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt, MD 20771 USA

The Sun upper atmosphere, the corona, is maintained to more than 1 MK, through processes that are still not fully understood. One of the main theories of the coronal formation suggests that the energy is dissipated through small scales (< 1E24 erg) and impulsive processes (Parker et al., ApJ, 1988). On 2020 May 30, the High Resolution Imager EUV (HRIEUV), onboard Solar Orbiter, was used to detect small (400 to 4000 km), short lived (10 to 100 s) EUV brightenings in the quiet Sun. Their contribution to coronal heating and their physical origin is actively studied. The aim of this work is to understand their physical origin. To do so, we simulate impulsively heated short loop, using the 1D hydrodynamics code HYDRAD (Bradshaw et al., A&A, 2003). We use two types of loops with distinct thermal behavior: cool (T < 0.1 MK) and hot (T > 0.1 MK) loops. The synthetic light curves of HRIEUV, SDO/AIA and Solar Orbiter/SPICE are computed and compared with those obtained from observations. The results showed that cool loops are good candidates to explain the physical origin of EUV brightenings, contrary to most hot loops models.

EP 6.5 Tue 17:30 ZHG101

A blowout jet in a self-consistent model of a solar coronal hole region — •Yajie Chen[1], Hardi Peter[1,2], Damien Przybylski[1], Lakshmi Pradeep Chitta[1], and Sudip Mandal[1] — [1]Max-Planck Institute for Solar System Research, 37077 Goettingen, Germany — [2]Institut für Sonnenphysik (KIS), 79110 Freiburg, Germany

Solar blowout jets are a distinct subclass of ubiquitous EUV and X-ray coronal jets. Most existing numerical models of blowout jets rely on prescribed initial magnetic field configurations or manual modifications of the magnetic field in the photosphere to trigger the jets. In this study, we first construct a comprehensive self-consistent 3D radiation MHD model of a solar coronal hole region, extending from the upper convection zone to the lower corona. Subsequently, we synthesize emissions in several EUV and X-ray passbands and identify a blowout jet self-consistently created in the model. The jet initially appears as a standard jet but later evolves into a blowout jet. The jet has a width of ~10 Mm and a lifetime of ~10 minutes. The plasma speeds within the jet reach approximately 180 km/s, and we also find a faint component in the synthesized X-ray images propagating at Alfvén speeds of ~500 km/s, which can be attributed to heating fronts. The corresponding magnetograms in the modeled photosphere show signatures of flux emergence and cancellation. These characteristics match well with those observed in blowout jets. By examining the magnetic field lines in and around the jet base, we validate the scenario that the jet is triggered by magnetic reconnection between the newly emerged twisted closed loops and the pre-existing open field lines.

EP 6.6 Tue 17:45 ZHG101

Comprehensive simulations of solar prominences — •Lisa-Marie Zessner, Robert Cameron, Sami K. Solanki, and Damien Przybylski — Max Planck Institute for Solar System Research, Göttingen, Germany

Solar prominences are cool and dense plasma clouds suspended in the hot solar corona. The heavy prominence plasma is supported against gravity by the magnetic field. Solar prominences are common features in the solar atmosphere, with diverse properties: they can have very different sizes, lifetimes, dynamics, and fine structures. If they become unstable, they can erupt and form the core of coronal mass ejections. Many aspects of their physics are still unknown, including their formation mechanism. We use the radiative magnetohydrodynamic code MURaM to simulate the formation and dynamics of a prominence in the solar atmosphere. MURaM includes the relevant physical processes to simulate the solar photosphere, chromosphere, and corona.

We create a stable, dipped magnetic arcade configuration in a 3D simulation box and let it evolve. In the course of the simulation, a solar prominence forms self-consistently. First, a dense plasma seed ejected from the chromosphere randomly settles into a magnetic dip of the field configuration and gets cooled by radiative losses. The resulting pressure drop then drives a strong inflow of hot plasma that condenses onto the feature. In this way, a dynamic, cool, and dense structure is built up in the solar corona. In this contribution, I will present the formation mechanism and properties of the simulated prominence for different setups of our configuration.

EP 6.7 Tue 18:00 ZHG101

Ubiquitous magnetic reconnection in filament eruptions revealed by Solar Orbiter at perihelion — •Song Tan[1,2], Alexander Warmuth[1], and Frédéric Schuller[1] — [1]Leibniz-Institut für Astrophysik Potsdam (AIP), An der Sternwarte 16 14482 Potsdam, Germany — [2]Institut für Physik und Astronomie, Universität Potsdam, Potsdam, Germany

Using unprecedented high-resolution observations (105 km/pixel) of Solar Orbiter Extreme Ultraviolet Imager, we reveal ubiquitous magnetic reconnection events in a failed filament eruption. Magnetic reconnection occurs between the filament and the surrounding magnetic field structures, with frequency and type far exceeding previous observations. These ubiquitous reconnections significantly affect the stability and eruption dynamics of the filament, leading to simultaneous coronal jets and failed eruptions. We propose a "magnetic erosion effect" concept, emphasizing the importance of frequent, fine-scale magnetic reconnection during the filament evolution.

EP 7: Planets and Small Bodies III

Time: Wednesday 11:00–12:05 Location: ZHG005

EP 7.1 Wed 11:00 ZHG005

Collecting a regolith sample from a near-Earth asteroid (NEA): A very fast sample return mission opportunity — •Martin Hilchenbach[1], Thorsten Kleine[1], Bastian Gundlach[2], Jens Biele[3], Stephan Ulamec[3], Tra-Mi Ho[4], Jan Thimo Grundmann[4], Carsten Güttler[3], Markus Patzek[3], Moritz Goldmann[3], Oliver Stenzel[1], Christian Renggli[1], Norbert Krupp[1], and Matthias Noeker[1] for the APOSSUM-Collaboration — [1]Max-Planck-Institute for Solar System Research, Göttingen, Germany — [2]Universität Münster, Institut für Planetologie, Münster, Germany — [3]Deutsches Zentrum für Luft- und Raumfahrt (DLR-MUSC), Cologne, Germany — [4]Institute of Space Systems (DLR), Bremen, Germany

The close flyby of asteroid (99942) Apophis would offer a unique opportunity to collect and return a regolith sample. The European Space Agency (ESA) is currently exploring the possibility within the RAMSES mission study to observe Apophis before its closest approach to Earth on Friday, April 13, 2029. We present the findings of our concurrent engineering (CE) studies evaluating the feasibility of a sample return capsule, named APOphiS SUrface saMpler (APOSSUM). The APOSSUM design envisions a detached, touch-and-go mission with semi-autonomous navigation and thruster-based control, collecting regolith using rotating brushes. By mid-March 2029, the capsule would be guided towards Earth, with a velocity offset of only a few tens of meters per second relative to the asteroid.

EP 7.2 Wed 11:15 ZHG005

Dust Measurements with the DESTINY+ Mission to the Active Asteroid (3200) Phaethon — •Harald Krüger[1,2], Masanori Kobayashi[2], Ralf Srama[3], Tomoko Arai[2], and DESTINY Dust Science Team[1,2,3] — [1]MPI für Sonnensystemforschung, Göttingen, Germany — [2]PERC, Chiba Institute of Technology, Narashino, Japan — [3]Institut für Raumfahrtsysteme, Universität Stuttgart, Germany

The DESTINY+ spacecraft will be launched by the Japanese Space Agency JAXA in 2028. The main mission target will be the active asteroid (3200) Phaethon, with a close flyby in 2030. Together with two cameras on board, the DESTINY+ Dust Analyzer (DDA) will perform in-situ measurements at Phaethon to solve essential questions related to the evolution of the inner Solar System, including heating processes and compositional evolution of small solar system objects. Phaethon is believed to be the parent body of the Geminids meteor shower and may be a comet-asteroid transition object. Such objects can likely provide information to better understand the nature and origin of mass accreted onto Earth. DDA is an upgrade of the Cassini Cosmic Dust Analyzer (CDA) which very successfully investigated the dust environment of the Saturnian system. DDA is an impact ionization time-of-flight mass spectrometer with integrated trajectory sensor, which will analyse sub-micrometer and micrometer sized dust particles. We give an overview of the DESTINY+ mission, the Dust Analyzer DDA and the science goals for the analysis of Phaethon dust, as well as interplanetary and interstellar dust to be measured en route to Phaethon.

EP 7.3 Wed 11:30 ZHG005

"Dark Comets" among the Near-Earth Asteroids — •Jessica Agarwal[1], Nicholas Attree[2], Pedro Gutierrez[2], Oriel Humes[1], and Manuela Lippi[3] — [1]TU Braunschweig, Germany — [2]Instituto de Astrofisica de Andalucia, Granada, Spain — [3]INAF, Osservatorio astrofisico di Arcetri, Firenze, Italy

The "dark comets" are a handful of near-Earth asteroids (NEAs) that have their orbits perturbed by a non-gravitational acceleration inconsistent with radiative processes of momentum transfer like radiation pressure and the Yarkowsky effect (Seligman et al., 2023, 2024, Farnocchia et al. 2023).

Asymmetric outgassing has been suggested as the next straightforward explanation of this acceleration, despite, but not inconsistent with a non-detection of emitted dust. Taylor et al. (2024) propose a model where the sublimating region would be located near the poles, and the rotation axes of the "dark comets" would have to be highly tilted. Thermophysical models (e.g., Schoerghofer & Hsieh, 2018), however, predict that, if at all, ice can be preserved in asteroids this close to the sun only in permanently shadowed polar regions, requiring a near-zero tilt.

This contribution reviews the available evidence concerning the "dark comets" and discusses the implications for the distribution and preservation of volatiles (i.e. water ice) in the asteroid population.

References: Seligman et al. (2023), PSJ, 4, 35; Seligman et al (2024) PNAS, 121, 51; Farnocchia et al. (2023), PSJ, 4, 29; Schoerghofer & Hsieh (2018), JGRP, 123, 2322.

EP 7.4 Wed 11:45 ZHG005

Investigating the activity of the disrupted asteroid 62412 (2000 SY178) — •Maria Mastropietro[1,2], Oriel Humes[1], Yoonyoung Kim[3], and Jessica Agarwal[1,2] — [1]Institut für Geophysik und Extraterrestrische Physik, TU Braunschweig, Germany — [2]Max Planck Institute for Solar System Research, Göttingen, Germany — [3]Department of Earth, Planetary and Space Sciences, UCLA, Los Angeles, USA

Dust emission from asteroids is often attributed to sublimation of exposed ice, causing comet-like activity in main-belt comets, or disruption from impacts or fast rotation, which in some cases can also expose subsurface ice for sublimation.

Asteroid 62412 (2000 SY178) exhibited dust emission after its 2013 perihelion, likely due to rotational destabilization due to its nature as a fast rotator [1]. Our analysis of archival data and pre-2024 perihelion observations shows significant changes in the asteroid's lightcurve amplitude and brightness after the 2013 activity, indicating changes in its shape and size.

If confirmed, the absence of reactivation in later perihelion passages may result from a lack of exposed ice or low surface temperatures due to high perihelion distance (2.9 AU).

[1] Sheppard, S. S. & Trujillo, C. 2015, AJ, 149, 44

Poster pitch: EP 10.15 (Markkanen)

EP 8: Members' Assembly

Time: Wednesday 12:15–13:30 Location: ZHG101

All members of the Extraterrestrial Physics Division are invited to participate.

EP 9: Exoplanets and Astrobiology

Time: Wednesday 16:15–18:15 Location: ZHG005

Invited Talk EP 9.1 Wed 16:15 ZHG005

A JWST View of Exoplanet Atmospheres: Everything We Dreamed Of, and More — •Laura Kreidberg — Königstuhl 17, 69117 Heidelberg

The recent launch of the James Webb Space Telescope (JWST) has revolutionized the field of exoplanet atmosphere characterization, thanks to its unprecedented sensitivity and broad wavelength coverage. In this talk, I will give a tour of the latest JWST results for transiting exoplanets, from gas giants down to rocky worlds. For the largest planets, I'll focus on the complex physical processes recently revealed in their atmospheres, including photochemistry, 3D effects, and cloud formation. Pushing down to smaller worlds, I'll share the first measurements of chemical composition for the elusive sub-Neptune population, and address the question of whether water worlds exist. In closing, I will give an update on the rapidly evolving topic of rocky planet characterization, including which (if any) rocky planets have atmospheres at all, and what their possible atmospheric compositions could be.

EP 9.2 Wed 16:45 ZHG005

How to improve the initial stellar characterisation of faint stars with transiting planets? — •Matthias Ammler-von Eiff[1], Daniel Sebastian[2], Jie Yu[3], Chen Jiang[1], and Eike W. Guenther[4] — [1]MPI for Solar System Research, Germany — [2]School of Physics and Astronomy, University of Birmingham — [3]School of Computing, Australian National University — [4]Thuringian State Observatory, Germany

The study of planetary systems in different Galactic environments is particularly interesting. These systems can be distant so that the host stars can be too faint for a precise characterisation with asteroseismology, interferometry, or ground-based spectroscopy. Also, extinction plays an important role.

An accurate determination of the host star parameters is essential to characterise planets in their orbit. In order to better understand the limitations for faint host stars and to identify possible solutions in preparation of PLATO, we reviewed the stellar parameters of all 36 CoRoT targets with planets detected.

We identified independent constraints, for instance from stellar density based on transit light curves and from distance from Gaia. We compared those to published estimates of extinction and effective temperature. This way, we can find out how accurate stellar parameters are and derive extinction more accurate than before. Eventually, we can derive the radii of the host stars in a homogeneous way. To our knowledge, this is the first time that the full set of CoRoT host stars is characterised with precise distances from Gaia.

EP 9.3 Wed 17:00 ZHG005

WASP-121 b's transmission spectrum observed with JWST/NIRSpec G395H reveals thermal dissociation and SiO in the atmosphere — •Cyril Gapp for the WASP-121 b JWST/NIRSpec transit-Collaboration — Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany

WASP-121 b has been established as a benchmark Ultra-Hot Jupiter, serving as a laboratory for the atmospheric chemistry and dynamics of strongly irradiated extrasolar gas giants. Here, we present and analyze WASP-121 b's transmission spectrum observed with NIRSpec G395H onboard the James Webb Space Telescope (JWST) and find evidence for the thermal dissociation of H_2O and H_2 on the planet's permanent day side. Additionally, we detect SiO at a statistical significance of $5.2\,\sigma$. Constraining the abundance of SiO and abundance ratios between Silicon and volatile atoms in WASP-121 b's atmosphere could help discriminate between possible migration histories of the planet. The three-dimensional nature of thermal dissociation on WASP-121 b's day side and recombination on its night side, however, poses a challenge to constrain molecular abundances and elemental abundance ratios from the transmission spectrum. To account for this, we implemented an atmospheric model in the `NEMESIS` framework that splits the planet's atmosphere into day side and night side. A retrieval applying our atmospheric model to WASP-121 b's transmission spectrum favors a higher H_2O abundance on the night side than on the day side, demonstrating the impact of hemispheric heterogeneity when attempting to constrain WASP-121 b's bulk H_2O inventory.

EP 9.4 Wed 17:15 ZHG005

Modeling the astrosphere of LHS 1140 — •Klaus Scherer[1], Konstantin Herbst[2], Eugene Engelbrecht[3], Stefan Ferreira[3], Jens Kleimann[1], and Juandre Light[3] — [1]Institut für Theoretische Physik IV, Ruhr-Universität Bochum, — [2]nstitut für Experimentelle and Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Germany — [3]Centre for Space Research, North-West University, 2520, Potchefstroom, South Africa

We have studied the 3D multifluid MHD structure of the LHS 1140 astrospheres. We discuss the shock structure of the stellar wind of LHS 1140 using four different models: HD and MHD single-fluid models, as well as multifluid models for both cases, including a neutral hydrogen flow from the interstellar medium. It is shown that the 3D multifluid positions of the termination shock differ remarkably from those found in the 3D ideal-single fluid hydrodynamic case. Here, we discuss especially the problems in choosing the stellar wind as well as the interstellar medium parameters. We present and discuss models with different initial parameter..

EP 9.5 Wed 17:30 ZHG005

Venus as an Exoplanet: Effect of varying stellar, orbital, planetary and atmospheric properties upon composition, habitability and detectability — •John Lee Grenfell[1], Jörn Helbert[1], Gabriele Arnold[1], Konstantin Herbst[2], Miriam Sinnhuber[3], and Heike Rauer[1,4] — [1]Department of Extrasolar Planets and Atmospheres (EPA), German Aerospace Centre, Berlin — [2]Centre for Planetary Habitability, University of Oslo — [3]Institute for Meteorology and Climate Research, Karlsruhe Institute of Technologie (KIT) — [4]Institute for Geological Sciences, Free University of Berlin

The newly selected Venus missions EnVISION and VERITAS (Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy) offer new opportunities for studying Venus but will also contribute to furthering our knowledge of Venus as an exoplanet. Hot rocky planets are favored targets due to generally more frequent transits than cooler Earth-like objects. In this work we simulate Venus as an exoplanet varying stellar, orbital, planetary and atmospheric parameters and study the effect upon atmospheric composition, climate and spectral detectability with the LIFE (Large Interferometer For Exoplanets) telescope.

EP 9.6 Wed 17:45 ZHG005

The Influence of Stellar Energetic Particles (SEPs) on the Atmosphere of Rocky Explanets — •Andreas Bartenschlager[1], M. Sinnhuber[1], J. L. Grenfell[2], N. Iro[2], B. Taysum[2], and K. Herbst[2] — [1]KIT, Karlsruhe — [2]DLR, Berlin

New instruments (JWST) open up the possibility of studying the composition of exoplanetary atmospheres in habitable zones. On explanets around active and quite M-stars like TRAPPIST-1 and LHS1140, the impact of SEPs and GCRs on the atmosphere plays an important role and is investigated with the ion chemistry model ExoTIC (Herbst et al. 2022). We perform model experiments with different N_2- or CO_2-dominated atmospheres, depending on the initial CO2 partial pressure, as well as humid and dry conditions (Wunderlich et al. 2020). A further specification is the distinction between dead and alive atmospheres, whose composition is characterized by initial lower/higher O_2 fractions. New modules give the possibility to simulate the ion chemistry's impact on the atmospheric composition of multiple ionization events with different strengths and frequencies, based on the observed flaring frequency of TRAPPIST-1 and the permanent GCR impact on LHS1140b. Preliminary results show a significant impact of SEP events on the chemical composition of the atmospheres, including biosignatures such as O_3 and N_2O, especially in the recovery of the ozone layer after multiple SEP events. These changes have an impact on the observed transmission spectra. The strength and structure of these impacts depend on the initial composition, in particular on the availability of O_2, N_2 and H_2O.

EP 9.7 Wed 18:00 ZHG005

Extraterretrial life? — •Karin Moelling — Institute of Medical Microbiology (IMM), Gloriatr 30, 8006 Zürich

Life on Earth is the only one we now of. Could there be life on one of the stars or exoplanets in the Universe? The main elements for life on Earth are "CHNOPS", which are universal and can give rise to nucleic acids, lipids and aminoacids, the essential macromolecules of terrestrial life. Life is characteized by repliction and evolution in response to environmental conditions.The simplest biomolecule for life om Earth is RNA,ribozymes or viroids. Also all metabolic processes in all species are very similar,and suggest a single origin, based on water, carbon and oxygen - are they also biomarkers for extraterrestrial life? On Earth life created its own living conditions, such as cyanobacteria which produced the toxic oxygen, now a biomarker of life. However, unaerobia live without oxygen. In meteorites 80 AA can be detected while we are only using 20. Our genetic code would not allow coding for them. Could there be different metabolism, genetic codes, biomarkers which lead to other forms of life. Could they be designed by alphaFold and AI, which may help us find unknown forms of life? Extremophiles and unique Earth properties will be discussed.

EP 10: Poster Session

Time: Thursday 11:00–12:30 Location: ZHG Foyer 1. OG

EP 10.1 Thu 11:00 ZHG Foyer 1. OG

The NASA Landolt mission — •Peter Plavchan — Mason Space Center MS 6D5, 4400 University Drive, George Mason University, Fairfax, Virginia, 22030 USA

The NASA Landolt mission is a timely PIONEERS program that will provide significant improvement in the accuracy of photometric measurements of absolute stellar fluxes. This will be accomplished with a high accuracy National Institute of Standards and Technology (NIST) calibrated suite of single-mode fiber-fed laser beacons which will be observable from selected ground-based observatory stations. Landolt will improve the photometric accuracy to <0.5% at visible (VIS) and near-infrared (NIR) wavelengths for >60 target stars. Such measurements can only be achieved by a space-based orbiting artificial star, where the physical photon flux is accurately known. Accuracy of absolute flux zero points is now the leading error budget term in the characterization of stars, be they standard stars or exoplanet hosts. Similarly, the accuracy of the ratio of the VIS/NIR absolute flux calibration zero point is the limiting error budget term in the Supernovae (SNe) Ia cosmological constraints on dark energy, a key science goal of the Nancy Grace Roman Space Telescope (Roman) and Vera C. Rubin Observatory (Rubin). Consequently, Landolt will enable the refinement of dark energy parameters, improve our ability to assess the habitability of terrestrial worlds, and advance fundamental constraints on stellar evolution.

EP 10.2 Thu 11:00 ZHG Foyer 1. OG

The Astropy Project: a community effort for a common software developent platform in Python — •Derek Homeier — Aperio Software Ltd. — The Astropy Team

Astropy is a project developing a common core platform for astronomical software in Python. Since the early 2010s Python has been recognised as a powerful alternative to data analysis platforms like IDL or Matlab, or compiled languages like Fortran and C++, for scientific data processing in the astrophysics research community. Numerical computation and visualisation needs led to significant contributions to evolving modules like Numpy and Matplotlib; yet individual needs also started to set off a proliferation of independent solutions. Astropy was created to foster an ecosystem of interoperable astronomy packages, sharing common coding standards and data APIs, to allow and actively encourage contributors from the community to invest their development work into a widely usable professional package.

A decade later this has made Python+Astropy now the dominant data-processing platform in astrophysical research. It is the basis for many observatories' data analysis tools, including STScI and JWST, and has a partner project in heliophysics, Sunpy. These efforts have been recognised by awards such as the IOP Publishing Top Cited Paper and most recently the Lancelot M. Berkeley-New York Community Trust Prize for Meritorious Work in Astronomy, and they are for the first time funded on a mid-long term basis under the NASA ROSES programme. With this growth the project has also evolved into a more formally organised and structured system.

EP 10.3 Thu 11:00 ZHG Foyer 1. OG

Water Megamasers: Rare Cosmic Beacons for Accurate SMBH Masses and Hubble Parameter Constraints — •Ahlam Farhan — Boğaziçi University, physics department, Istanbul, Turkiye

Extragalactic water vapour maser emission at 22 GHz (H2OMM) has been traced with remarkable accuracy to within a few parsecs of accretion discs around supermassive black holes (SMBHs). High-resolution VLBI observations demonstrate their ability to measure SMBH masses beyond the Milky Way and constrain the Hubble parameter to within 4% accuracy, as the Megamaser Cosmology Project (MCP) shows.

Despite these capabilities, H2OMMs are rare, with only 200 detections among over 6,000 surveyed galaxies. The complex and poorly understood physical conditions required for their formation, make it challenging to pinpoint the ideal galaxies to hunt new maser galaxies. Statistical studies are therefore crucial to identify trends that can guide future surveys toward higher detection rates.

Our study focuses on Active Galactic Nuclei (AGN) properties and highlights that galaxies with luminous dense gas tracers (e.g., HCO+, HCN) and weak 6.4 keV Fe Kα emission are more likely to host H2OMMs. These findings offer a pathway to optimise future searches, enhancing both cosmological measurements and our understanding of AGN environments.

EP 10.4 Thu 11:00 ZHG Foyer 1. OG

Stochastic High Frequencies in massive stars — •Julieta Paz Sanchez Arias[1], Suryani Guha[1,2], and Alejandra Christen[3] — [1]Astronomical Institute, Czech Academy of Science, Fričova 298, 251 65 Ondřejov, Czech Republic. — [2]Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic. — [3]Instituto de Estadistica, Universidad de Valparaiso, Valparaiso, Chile.

The light curves of massive OB stars are known to be affected by red noise, which translates into a power excess in the low-frequency range. The origin of these stochastic low frequencies has been proposed to be convection and/or granulation at the stellar surface, internal gravity waves stochastically excited, and inhomogeneities in the winds of massive stars. However, the underlying physics of their origin is still poorly understood. Thanks to a new mathematical method for frequency analysis (the Empirical Mode Decomposition method), we have found frequencies excited at high frequency ranges in massive stars, which seem to be connected also with a stochastic process. In this work, we present numerical experiments with ARFIMA processes to model stochastic high frequencies (SHF) signals and detailed frequency analysis of a group of massive stars observed with TESS mission that exhibit SHF. The presence of these newly detected SHF provides additional tools to understand the origin of the red noise in massive stars.

EP 10.5 Thu 11:00 ZHG Foyer 1. OG

Near-infrared characterization of evolved massive stars in M31 and M33 — •Michaela Kraus[1], María Laura Arias[2], Michalis Kourniotis[1], Andrea Torres[2], Lydia Cidale[2], and Marcelo Borges Fernandes[3] — [1]Astronomical Institute AV CR, Ondrejov, Czech Republic — [2]Universidad Nacional de La Plata, Argentina — [3]Observatório Nacional, Rio de Janeiro, Brazil

The upper region of the Hertzsprung-Russell diagram is populated by massive stars in a diversity of evolutionary states, and the classification of these stars is often based on observed characteristics exclusively in the optical spectral range. The near-infrared regime provides useful complementary information that can help resolving ambiguities in stellar classification and add valuable information about circumstellar envelopes or late-type companions. We present new, near-infrared medium-resolution K-band spectra for a sample of seven evolved massive stars, four in M31 and three in M33. Based on the spectral appearance of the objects, we classify three objects as B[e] supergiants, of which two are found to be surrounded by dense and warm molecular gas rings. One B[e] supergiant and one Luminous Blue Variable display dense ionized winds, and one object is possibly a Luminous Blue Variable in outburst. The spectra of the remaining two objects indicate the presence of the red supergiant. Whether these are physical companions to the hot objects or they are just close in projection needs to be investigated.

EP 10.6 Thu 11:00 ZHG Foyer 1. OG

OCEANS - Overcoming challenges in the evolution and nature of massive stars — •Michaela Kraus and The OCEANS Consortium — Astronomical Institute AV CR, Ondrejov, Czech Republic

Massive stars are the cornerstone of the dynamic and chemical evolution of the cosmos, enriching it as they evolve with chemically processed material that is blown away from their surface by energetic winds and eruption processes. Despite their importance, their evolution from cradle to death as spectacular supernova explosions still poses many mysteries due to crucial knowledge gaps in the physical processes taking place in their interior and atmosphere and the mutual influence by close-by siblings. This poster presents the project OCEANS funded by the European Union. Our goal is to elucidate the physical properties and evolution of massive stars impacted by companions, as well as their contribution to the generation of gravitational waves. For this, we established a multidisciplinary, international network of researchers from Europe and America with expertise in various disciplines, and with background in both theory and observations. We exploit the avalanche of public data archives and develop machine learning algorithms to detect massive stars in binary and multiple systems, classify them, and create statistically meaningful samples for diverse evolutionary states. We also develop progressive methods of signal processing for the analysis of the stellar properties, and cutting-edge numerical codes to unveil the impact of stellar interaction and mass ejection on the evolution of the stars and stellar systems.

EP 10.7 Thu 11:00 ZHG Foyer 1. OG

Revealing the pulsation-induced mass loss of blue supergiants and its interplay with the interstellar medium — Michaela Kraus, Julieta Sánchez Arias, Peter Németh, Michalis Kourniotis, •Olga Maryeva, Dieter Nickeler, Suryani Guha, and Kuljeet Saddal — Astronomical Institute of the Czech Academy of Sciences, Ondrejov, Czech Republic

Massive stars play an important role in many astrophysical processes: from the formation of heavy elements in the Universe to a significant influence on the evolution of their host galaxies and star formation. One of the key parameters required to accurately model these processes, alongside luminosity, is the mass-loss rate. In the talk we will present a new ambitious project devoted to the determination of the mass loss rate for blue supergiants (BSGs) – evolutionary phase through which all massive stars pass. The goal of the project is to quantify the total amount of mass loss of BSGs from their winds and pulsations as improved input to stellar evolution calculations, and to gain insight into the mutual interaction between stellar pulsations, winds and their impact on shaping the local interstellar medium. In order to achieve our goal, we will combine calculation of the evolution and internal structure of massive stars (MESA code); computation of pulsations (GYRE code); stellar atmosphere and wind modeling (CMFGEN) – with collected time-series of spectroscopic and photometric observations. Also, we will use the obtained wind parameters in 2D and 3D magneto-hydrodynamics calculations to study its interaction with the interstellar medium.

EP 10.8 Thu 11:00 ZHG Foyer 1. OG

New Insights into Stellar Activity through Simultaneous High-Resolution Spectroscopy and Photometry — •Jakob Adamczewski[1,2] and Eike Günther[2] — [1]Göttingen University, Göttingen, Germany — [2]Thüringer Landessternwarte, Tautenburg, Germany

To address unresolved questions about activity processes, one of the most active systems, UY Pic A, in the PLATO southern field was observed using simultaneous TESS photometry and ground-based high-resolution spectroscopy with the PLATOSpec spectrograph. Our study aims to determine the sizes of coronal loops, establish the relationship between radial velocity variations and starspot dynamics, and investigate the effects of magnetic coupling between two active stars and potentially their planets.

EP 10.9 Thu 11:00 ZHG Foyer 1. OG

Stellar activity in the solar system and beyond: Earth as an exoplanet — •Alexander Siebelts — Karlsruher Institut für Technologie(KIT)

With their increasing number of discoveries, research in the habitability of exoplanets becomes an increasing topic of interest. In several cases, atmospheres on exoplanets have already been detected. Even if we assume that an Earth-like atmosphere is present on an exoplanet in the habitable zone around its host star, the orbital and stellar conditions it lives in have a profound effect on the climatological conditions of its atmospheres, the weather, and ultimately the habitability. In the scope of a Master's thesis, several experiments have been conducted to research the effect that changes on orbital parameters have on the climatological conditions on such an exoplanet. With the climate model ICON, simulations of Earth have been done as an Earth-like exoplanet. In a first step, the research included the adaptation of the solar spectrum, the topography and composition of its surface and the magnetic field, but was later limited to the obliquity and eccentricity of the planet's orbit, the distance and solar intensity simulated by the solar constant, and the angular velocity of the planet. The model simulations provide insight into the changes in the atmospheric dynamic and climatology under extreme conditions. While the changes made to the obliquity show a more realistic transformation of the extent of Earth's seasons, the changes made to the angular velocity provide unrealistic results. The effect of all parameters is heavily outweighed by the changes made to the solar constant.

EP 10.10 Thu 11:00 ZHG Foyer 1. OG

EPP-climate link by reactive nitrogen polar winter descent:science studies for the EE11 candidate mission CAIRT — •Stefan Bender[1], Bernd Funke[1], Manuel López Puertas[1], Maya Garcia-Comas[1], Gabriele Stiller[2], Thomas von Clarmann[2], Michael Höpfner[2], Björn-Martin Sinnhuber[2], Miriam Sinnhuber[2], Quentin Errera[3], Gabriele Poli[4], and Jörn Ungermann[5] — [1]IAA-CSIC, Spain — [2]KIT, Germany — [3]BIRA, Belgium — [4]IAP "Nello Carrara", Italy — [5]FZJ, Germany

Polar winter descent of NOy produced by energetic particle precipitation (EPP) in the mesosphere and lower thermosphere affects polar stratospheric ozone by catalytic reactions. This, in turn, may affect regional climate via radiative and dynamical feedbacks. NOy observations by MIPAS/Envisat during 2002–2012 have provided observational constraints on the solar-activity modulated variability of stratospheric EPP-NOy. These constraints have been used to formulate a chemical upper boundary condition (UBC) for climate models in the context of solar forcing recommendations. ESA's Earth Explorer 11 candidate Changing Atmosphere Infra-Red Tomography (CAIRT) will observe the atmosphere from about 5 to 115 km with an across-track resolution of 30 to 50 km within a 500 km wide field of view. CAIRT will provide NOy and tracer observations from the upper troposphere to the lower thermosphere with unprecedented spatial resolution. We present the science studies to assess its potential to advance our understanding of the EPP-climate link and to improve upon the aforementioned constraints in the future.

EP 10.11 Thu 11:00 ZHG Foyer 1. OG

Amplitudes of Magnetopause Surface Waves: Comparison of THEMIS Observations with MHD Theory — •Adrian Pöppelwerth[1], Niklas Grimmich[1], Rumi Nakamura[2], and Ferdinand Plaschke[1] — [1]Institut für Geophysik und Extraterrestrische Physik, TU Braunschweig, Braunschweig, Deutschland — [2]Institut für Weltraumforschung, Österreichische Akademie der Wissenschaften, Graz, Österreich

The Earth's magnetopause is the boundary between the terrestrial and the interplanetary magnetic fields. Variations in solar wind pressure and structures originating from the solar wind or foreshock regions induce constant dynamic motion of this boundary. In addition, a high velocity shear between the magnetosheath and magnetospheric plasmas can trigger the Kelvin-Helmholtz instability. All these interactions can generate waves on the magnetopause, which can either propagate along the magnetopause towards the nightside or form standing surface waves. These surface waves excite fluctuations within the ambient plasma on either side of the magnetopause and allow them to propagate away from the source region. According to magnetohydrodynamic (MHD) theory, the amplitude of these waves should decrease exponentially with distance from the boundary.

With the multi-spacecraft mission Time History of Events and Macroscale Interactions during Substorms (THEMIS), we are able to observe surface waves at different distances from the magnetopause. Here we present preliminary findings that compare these spacecraft observations with predictions from MHD theory.

EP 10.12 Thu 11:00 ZHG Foyer 1. OG

An exact analytical solution for the weakly magnetized flow around an axially symmetric paraboloid, with application

to magnetosphere models — •Jens Kleimann[1] and Christian Röken[2] — [1]Theoretische Physik IV, Ruhr-Universität Bochum, Germany — [2]Institut für Philosophie, Universität Bonn, Germany

Rotationally symmetric bodies with longitudinal cross sections of parabolic shape are frequently used to model astrophysical objects, such as magnetospheres and other blunt objects, immersed in interplanetary or interstellar gas or plasma flows. We discuss a simple formula for the potential flow of an incompressible fluid around an elliptic paraboloid whose axis of symmetry coincides with the direction of incoming flow. Prescribing this flow, we derive an exact analytical solution to the induction equation of ideal magnetohydrodynamics for the case of an initially homogeneous magnetic field of arbitrary orientation being passively advected in this flow. Our solution procedure employs Euler potentials and Cauchy's integral formalism based on the flow's stream function and isochrones. Furthermore, we use a particular renormalization procedure that allows us to generate more general analytical expressions modeling the deformations experienced by arbitrary scalar or vector-valued fields embedded in the flow as they are advected first toward and then past the parabolic obstacle. Finally, both the velocity field and the magnetic field embedded therein are generalized from incompressible to mildly compressible flow, where the associated density distribution is found from Bernoulli's principle.

EP 10.13 Thu 11:00 ZHG Foyer 1. OG

Permittivity sensor for radar measurements and complex permittivity analysis of the ice crust on Jupiter's moon Europa — •Fabian Becker, Enrico Ellinger, and Klaus Helbing — Bergische Universität Wuppertal, Wuppertal, Deutschland

The icy moons in our solar system are gaining significant attention as targets for upcoming space missions. This interest stems from the substantial reservoirs of liquid water hidden beneath their icy surfaces, which could potentially harbour conditions suitable for extraterrestrial life. Following the era of orbital missions that have studied moons like Europa, Ganymede, Callisto, and Enceladus, the next step is to design and deploy lander missions.

Our approach to exploring the ice crust and potentially traversing the thick ice layer to reach the liquid water beneath involves using melting probes. For these probes, a specialized sensor system has been developed to measure the surrounding ice's complex permittivity ε_r^*. This sensor system will provide valuable preliminary information about the structure and composition of the moon's ice crust, offering key insights into its physical and chemical properties.

This poster will demonstrate how such a sensor is integrated into a melting probe, the precision with which it measures both the real and imaginary components of permittivity and the underlying principles of its operation. Furthermore, it will highlight how advanced calibration techniques and simulations have enabled more accurate measurements, enhancing the sensor's performance and reliability.

EP 10.14 Thu 11:00 ZHG Foyer 1. OG

Integration of Scientific Payloads into the TRIPLE-IceCraft Melting Probe for the Exploration of Subglacial Lakes — •Max Schmit[1], Jan Audehm[1], Clemens Espe[2], Marco Feldmann[2], Gero Francke[2], Mia Giang Do[1], Christoph Günther[1], Dirk Heinen[1], Lukas Michels[1], Fabian Schöttler[2], Christopher Wiebusch[1], and Simon Zierke[1] — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]GSI - Gesellschaft für Systementwicklung und Instrumentierung mbH, Aachen, Germany

Europa, one of Jupiter's moons, is a top contender in the search for extraterrestrial life, with evidence suggesting a global ocean beneath its icy crust. Upcoming missions aiming to explore this hidden water reservoir will require drilling through Europa's thick ice shell. The TRIPLE projectline (Technologies for Rapid Ice Penetration and Subglacial Lake Exploration) is initiated by the German Space Agency at DLR to develop the key technologies for such missions. The TRIPLE-IceCraft is a modular melting probe designed to carry a range of scientific payloads through ice. These payloads include the nanoAUV, a small autonomous submarine, instruments for in-situ water analysis and a forefield reconnaissance system. Integrating these payloads into the TRIPLE-IceCraft structure is crucial for exploring subglacial lakes and will pave the way for future missions to explore Europa's subglacial ocean. This poster highlights the integration of these scientific payloads into the TRIPLE-IceCraft and presents initial test results.

EP 10.15 Thu 11:00 ZHG Foyer 1. OG

Characterizing cometary dust: Insights from advanced modeling of scattered light — •Johannes Markkanen — Institut für Geophysik und Extraterrestrische Physik, TU Braunschweig, Germany

Analyzing the scattered light produced by cometary dust particles can provide valuable insights into their physical properties, including size, morphology, and composition. However, interpreting this scattered light presents significant challenges for standard computational methodologies. Moreover, the solutions to inverse problems are often non-unique, suggesting that reliance on a single observable may lead to potentially erroneous conclusions.

In this presentation, I will offer a comprehensive analysis of the observed polarization and color in cometary comae, utilizing cutting-edge numerical light-scattering solvers. I will demonstrate that integrating multi-instrument observations with self-consistent numerical light scattering and dust dynamical modeling can substantially enhance the reliability of the derived physical properties of cometary dust. Additionally, this approach allows us to investigate potential ongoing non-stationary processes, such as fragmentation and sublimation, within the coma.

EP 10.16 Thu 11:00 ZHG Foyer 1. OG

Non-thermal motions in the solar corona — •Arjun Kannan, Hardi Peter, Yajie Chen, and Damien Przybylski — Max Planck Institute for Solar System Research, 37077 Göttingen, Germany

Almost all spectra from the Solar atmosphere show a line width in excess of the pure thermal broadening. Extreme UV (EUV) emission lines are formed in the transition region and the corona under optically thin conditions. Hence, the non-thermal broadening of these lines is expected to be mainly due to non-resolved motions, e.g., waves or turbulence. However, observations show that non-thermal motions in the upper solar atmosphere do not depend on spatial resolution, hinting at a mechanism operating well below currently resolvable scales. So far, general 3D models have failed to reproduce the observed non-thermal motions. Our study aims to investigate the latest high-resolution 3D models of the quiescent Solar regions to see if, at sufficient resolution, these models match observations. We synthesize emission in the respective EUV line and calculate the spectra to derive a synthetic map of the non-thermal line width, which can then be compared to real observations. This will provide insights into the extent to which the current 3D MHD models represent the solar upper atmosphere. This proof is essential for the future inclusion of these models in interpreting the data from new complex coronal spectroscopic observations, particularly with the upcoming MUltislit Solar Explorer (MUSE).

EP 10.17 Thu 11:00 ZHG Foyer 1. OG

Chromospheric Fe I lines in the NUV solar spectrum — •Edvarda Harnes[1,2], Smitha Narayanamurthy[1], Andreas Korpi-Lagg[1,3], Damien Przybylski[1], and Sami Solanki[1] — [1]Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany — [2]Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [3]Aalto University, Department of Computer Science, Konemiehentie 2, 02150 Espoo, Finland

In the near-ultraviolet (NUV) solar spectrum there are several Fe I lines that show very broad profiles typical of chromospheric lines. The diagnostic potential of these spectral lines is largely unexplored due to a lack of high-resolution observations. With the successful flight of the SUNRISE III balloon-borne observatory we have for the first time full spectro-polarimetric data at high spatial resolution of this region, and ground-based observatories can also observe the broad Fe I lines around 400 nm. The goal of this work is to investigate and discuss the formation properties of these spectral lines and their suitability for interpreting observations. An initial investigation was done by synthesizing a selection of lines in the FAL one-dimensional semi-empirical solar atmosphere models using the non-LTE radiative transfer code RH. We found that the lines are significantly affected by overionization in the wings and scattering in the chromospheric line cores. The next step is to investigate the lines in a dynamic atmosphere of a 3D radiation-MHD model, made with the chromospheric extension of MURaM, and results from this will be presented.

EP 10.18 Thu 11:00 ZHG Foyer 1. OG

Diagnostics of comprehensive simulations of the chromosphere — •Patrick Alexander Ondratschek[1], Damien Przybylski[1], H.N. Smitha[1], Robert Cameron[1], Sami K. Solanki[1], and Jorrit Leenaarts[2] — [1]Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany — [2]Institute for Solar Physics, Stockholm, Sweden

The chromosphere is a region of the solar atmosphere above the photosphere and below the millions of Kelvin hot corona. It is a place of extremes where multiple physical transitions take place. In the photosphere, the dynamics are dominated by the plasma pressure. As the density decreases with height, the magnetic field becomes dynamically important. The detailed processes that heat the chromosphere and provide the mass for the corona are only poorly understood. Many studies of the chromosphere are based on a few strong spectral lines that carry the necessary diagnostic potential to infer physical quantities such as e.g. temperature, velocity, and magnetic field. These spectral lines form under nonlocal thermodynamic equilibrium conditions and are difficult to interpret. We aim to understand line formation in the solar chromosphere by synthesizing spectral lines from numerical models. Previous models of the solar chromosphere resulted in too-faint intensities and too-narrow line widths when compared with observations. We use a new model of the chromosphere simulated with the MURaM-ChE code to study the formation of the Mg II h&k and Ca II 8542 lines. We find an improved match with the observations, signifying a step forward in our understanding of the chromosphere.

EP 10.19 Thu 11:00 ZHG Foyer 1. OG

Helium at the terrestrial planets - recent spacecraft observations — •Markus Fränz and Harald Krüger — Max-Planck-Institut fuer Sonnensystemforschung, 37077 Goettingen, Germany

The Sun is a primary source of Helium in the inner solar system. At the terrestrial planets radio active decay can also contribute to the Helium budget in the exospheres. The third source of Helium is the interstellar neutral gas. Recent missions to planet Mercury are giving new interesting insights on the role of the different sources. The MESSENGER spacecraft was launched in 2004, and between March 2011 and April 2015 it was the first spacecraft in orbit around Mercury. The FIPS instrument on board MES- SENGER measured the ion composition in the vicinity of Mercury and in the inner solar system. We aim to determine the origin of He+ ions in the inner solar system and in the environment of Mercury, continuing earlier work by Gershman et al. (2013). We have analyzed measurements of He+ and He2+ ions made by the FIPS instrument during the interplanetary cruise phase of MESSENGER and its entire orbital mission at Mercury. We de- termined the spatial distributions of He+ ions in the regions sampled by MESSENGER during that period and compare the spectra to a similar observation by the MPPE-MSA instrument onboard BepiColombo. We here consider two possible sources of He+: (1) interstellar neutral helium ionized close to Mercury and (2) solar He2+ ions converted close to or at the surface of Mercury. We also compare the observed densities with a simple model of the ionization of the interstellar helium flow.

EP 10.20 Thu 11:00 ZHG Foyer 1. OG

Simulation of sunspots in the chromosphere and further comparison of the results with observations — •Aswathi Krishnan Kutty, Robert Cameron, Damien Przybylski, and Sami Solanki — Max Planck Institute for Solar System Research, Goettingen

At the photospheric level, sunspots consist of a dark central umbra, scattered with umbral dots, surrounded by a filamentary penumbra that is on average considerably brighter than the umbra but darker than the surrounding quiet Sun. In the photosphere, the nearly horizontal Evershed flow is directed outward from the outer edge of the umbra along penumbral filaments. On the other hand, the flow is reversed in the chromosphere, the layer just above the photosphere where the plasma flows inwards and towards the umbra. Radiative MHD codes by, e.g., Heinemann et al. (2007) and Rempel et al. (2009) have been used to simulate sunspots at the photosphere and below. The chromospheric component of the atmosphere near and above a sunspot is not well understood from a theoretical perspective. In this poster, we will present preliminary simulations extending the previous simulations higher into the solar atmosphere.

EP 10.21 Thu 11:00 ZHG Foyer 1. OG

Investigating high-speed outflows from a coronal hole with UV spectroscopy — •Mario Roco-Moraleda[1], Luca Teriaca[1], Pradeep Chitta[1], Ziwen Huang[1], Hardi Peter[1,2], and Sami Solanki[1] — [1]Max-Planck-Institut für Sonnensystemforschung, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany — [2]Institut für Sonnenphysik (KIS), Georges-Köhler-Allee 401a, 79110 Freiburg, Germany

Coronal holes have been known since decades to be the main source regions of the solar wind. Recent very high resolution observations from the HRIEUV telescope of the EUI instrument on Solar Orbiter show evidence that the fast solar wind and the Alfvénic slow wind originate from largely unipolar, open field region characterized by low emission in coronal lines (T = 1 MK). Those observations draw a connection between speeds on the plane of sky of about 100-150 km/s at a few tens of megameter above the solar surface and picoflare jets, with kinetic energy content in the range of 10^21 to 10^24 erg, at the base of the corona in these dark areas.

However, classical spectroscopic observations (line of sight velocities) in lines formed at the base of the corona (T=0.6 MK) do not show evidence of upflow velocities above about 10 km/s, difficult to reconcile with the HRIEUV observations.

We revisit high quality SUMER observations of an on-disk equatorial coronal hole. We perform a very accurate wavelength calibration and analysis of the spectral profiles to detect signature of high-speed flows occurring at spatial scales below 1” resolution of the instrument.

EP 10.22 Thu 11:00 ZHG Foyer 1. OG

A new categorization of coronal dimmings — •Bernhard Kliem and the ISSI Team Coronal Dimmings — University of Potsdam, Institute of Physics and Astronomy, 14476 Potsdam

A new, physics-based categorization of coronal dimmings has recently been proposed by an ISSI International Team ”Coronal dimmings and their relevance to the physics of solar and stellar coronal mass ejections” (Veronig, Dissauer, Kliem, Downs et al. 2025, LRSP, subm.) The new categories were defined by considering the magnetic flux systems involved in solar coronal mass ejections (CMEs) and the principal magnetic reconnection processes between them. These are proposed to replace the morphology-based traditional categories of Core and Secondary Dimmings. They are expected to aid the physical interpretation of the often complex dimming morphologies. The flux systems are: the erupting core flux (a magnetic flux rope, MFR), the strapping flux (external poloidal field) yielding force-free MFR equilibrium, closed exterior flux, and open flux (an ambient coronal hole). The principal reconnection processes are: strapping-strapping (”flare”) reconnection, rope-strapping reconnection, rope-exterior reconnection, rope-open-flux reconnection, and leg-leg reconnection of the erupting flux rope. These lead to Stationary, Shrinking, and Moving Flux-rope Dimmings, Strapping-flux Dimmings, Exterior Dimmings, and Open-flux Dimmings. Schematics and illustrative examples will be shown.

EP 11: Sun and Heliosphere IV

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

EP 11.1 Thu 13:45 ZHG101

Magnetic structure of coronal dark halos — •Jonathan Nölke[1], Johann Hirzberger[1], Hardi Peter[1,2], Sami Solanki[1], and Pradeep Chitta[1] — [1]Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany — [2]Institut für Sonnenphysik (KIS), Freiburg, Germany

At low temperatures around 1 MK, distinct regions of the solar corona exhibit emission levels significantly below those of the quiet Sun. A prominent example are dark halos surrounding active regions, which are sometimes misidentified as coronal holes (CH). While the well-studied CHs owe their darker appearance to open magnetic field lines, the formation mechanism of dark halos remains unclear.

On 5 November 2021, Solar Orbiter and the Solar Dynamics Observatory observed the dark halo surrounding active region NOAA 12893. One of its patches overlaps with an adjacent CH, providing a unique opportunity to directly compare the two phenomena.

The magnetic field underneath the dark halo is weaker than in brighter areas. At its outer boundaries, it shows even lower field strengths than those typically found in the quiet Sun. In contrast to the reduced coronal emission at temperatures around 1 MK, at higher temperatures the emission is stronger. This shows a clear difference to

CHs, which characteristically exhibit reduced emission at these temperatures. We further demonstrated that unlike the embedded CH, the dark halo patches are magnetically closed.

Our combined EUV and magnetic field observations suggest that dark halos result from reduced heating.

EP 11.2 Thu 14:00 ZHG101

High-resolution observations of small-scale activity in coronal hole plumes — •Ziwen Huang[1], Chitta Lakshmi Pradeep[1], Luca Teriaca[1], Regina Aznar Cuadrado[1], Hardi Peter[1,2], Sami K. Solanki[1], Thomas Wiegelmann[1], and Ferdinand Plaschke[3] — [1]Max Planck Institute for Solar System Research, Göttingen, Germany — [2]Institut für Sonnenphysik (KIS), Freiburg, Germany — [3]Institut für Geophysik und extraterrestrische Physik, Technische Universität Braunschweig, Braunschweig, Germany

Coronal hole plumes, largely radial ray-like structures located in coronal holes, are key targets for studying magnetohydrodynamic waves and solar wind origins. The plume bases are riddled with small-scale transients. We study three plumes within an equatorial coronal hole observed on 13 October 2022 by the High Resolution EUV telescope, part of EUI on board Solar Orbiter. By applying two different identification techniques, we detect tens to hundreds of small-scale brightenings at the plume bases. The statistical analysis of their properties (intensity, lifetime, area, shape, velocity) indicates that the majority of the observed brightenings are characterized by their small-scale nature, transient behavior, and display slightly elongated morphologies near the plume bases. Most of the brightenings appear to move with a velocity component in the plane of sky of less than 10km/s. Their de-projected 3D velocities are found to be substantially lower than the apparent outflow velocities (about 100km/s) detected at greater heights. We propose that the base brightenings may be related to either wave-driven Type I spicules or interchanging reconnections.

EP 11.3 Thu 14:15 ZHG101

Quasi-separatrix-layers channel solar wind outflows in coronal hole — •Kamlesh Bora, Pradeep Chitta, Yajie Chen, and Damien Przybylski — Max-Planck Institute for Solar System Research, 37077 Göttingen, Germany

Observations indicate that small-scale, transient jetlets at the base of plumes and upflows within coronal holes contribute substantially to the mass and energy flux of the solar wind. We use three-dimensional radiation magnetohydrodynamic (MHD) simulations of a coronal hole plume, conducted with the MURaM code, to examine the magnetic origins and driving mechanisms of these upflows/jets in the solar atmosphere. Our simulations show that interactions between the magnetic field of the plume with the surrounding like-polarity magnetic patches creates a strong quasi-separatrix layer (QSL), characterised by a filamentary fine structure. We analyse the resulting plasma flows and temperature structure, comparing them with synthesised 174 Å Extreme Ultraviolet Imager (EUI) emission at this QSL. We noted a transition from cooler downflows in the lower atmosphere to persistent hotter upflows in the corona at the QSL, with a substantial mass flux of $10^{-8} g\ cm^{-2}\ s^{-1}$, that could in principle be channelled as the solar wind outflow. Our simulations go beyond the traditional picture of upflows originating from an interchange reconnection between open and closed field lines, and show the important role of QSLs in the formation of the solar wind.

EP 11.4 Thu 14:30 ZHG101

Insights into the energy partition of solar flares and STIX spectral response calibration via simultaneous X-ray spectral fitting of CH-2 XSM and SO STIX data. — •Jake Mitchell[1], Alexander Warmuth[1], Frederic Schuller[1], Song Tan[1], Fanpeng Shi[1], Bhuwan Joshi[2], and Mithun N.P.S[2] — [1]Leibniz Institute For Astrophysics, Potsdam, Germany — [2]Udaipur Solar Observatory, Udaipur, India

Understanding the energy partition between thermal and non-thermal particles during the flaring process is an essential component in achieving a more holistic view of the physical processes that drive solar flares. Using both PyXspec and the python based Sunkit-Spex we analyse data from a sample of 18 flares selected due to a co-alignment of the Chandrayaan-2 XSM (Solar X-ray Monitor) and the Solar Orbiter STIX instrument. Contemporaneous data from these two instruments enables simultaneous fitting of the relatively soft and hard X-ray spectra respectively. We compare results from individual and simultaneous fits to the XSM and STIX data and investigate the effect of the inclusion of the softer X-rays from XSM into the modelling process whilst also gaining valuable insights into the intercalibration between XSM and STIX.

EP 11.5 Thu 14:45 ZHG101

CoSEE-Cat: the Comprehensive Solar Energetic Electron Event Catalogue — •Alexander Warmuth, Frederic Schuller, Song Tan, and Jake Mitchell — Leibniz-Institut für Astrophysik Potsdam (AIP)

We present a comprehensive catalogue of solar energetic electron (SEE) events derived from joint observations of remote-sensing and in-situ instruments on Solar Orbiter. The Energetic Particle Detector (EPD) is used to characterize the properties of energetic electrons in-situ and obtain injection times at the Sun. Timing, position, and magnitude of corresponding X-ray flares are identified with the Spectrometer/Telescope for Imaging X-rays (STIX), which is complemented by the Extreme Ultraviolet Imager (EUI) which provides additional context on the flare evolution and eruptive phenomena. The Metis coronagraph and the SoloHI heliospheric imager characterize the associated coronal mass ejection. Finally, type III radio bursts detected by the Radio and Plasma Waves (RPW) instrument are used to link the eruptive solar events to the SEE events detected in-situ. We discuss the contents of the catalogue, how the various parameters were determined, and discuss statistical results on SEE events obtained from the catalogue.

EP 11.6 Thu 15:00 ZHG101

STEREO REleASE: Real time solar energetic proton forecasting — •Henrik Dröge[1], Bernd Heber[1], Alexander Kollhoff[1], Patrick Kühl[1], Olga Malandraki[2], and Arik Posner[3] — [1]Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Germany — [2]National Observatory of Athens, Athens, Greece — [3]NASA/HQ, Washington, DC 20546, USA

Sudden Solar Energetic Particle (SEP) events can have a major impact on technology and humans in space. Therefore forecasts and early warning systems working to support those missions are desirable. One example is REleASE, which utilizes the close correlation of near relativistic electrons and the slower but more hazardous protons. The original HESPARIA REleASE system uses electron measurements from SOHO/EPHIN and ACE/EPAM to issue short term warnings before there is a significant flux increase of >20 MeV protons at L1.

We now adapted the method to work with the High Energy Telescope (HET) and the Solar Electron Proton Telescope (SEPT) on board of STEREO-A. The resulting forecasts are publicly available in real time. With now two REleASE systems operational we have the unique possibility to directly compare the forecasts from different points in the heliosphere and test the accuracy depending on the magnetic connection.

Furthermore, we gained valuable insights from adapting the method to the SEPT that uses the magnet/foil technique to separate electrons from ions, which can pose several difficulties.

EP 11.7 Thu 15:15 ZHG101

Evolution of fundamental and harmonic sources in LOFAR type III radio burst images — •Christian Vocks[1], Mario Bisi[2], Bartosz Dabrowski[3], Diana Morosan[4], Peter Gallagher[5], Andrzej Krankowski[3], Jasmina Magdalenic[6], Gottfried Mann[1], Christophe Marque[6], Barbara Matyjasiak[7], Hanna Rothkaehl[7], and Pietro Zucca[8] — [1]Leibniz Institute for Astrophysics Potsdam (AIP), Germany — [2]RAL Space, United Kingdom — [3]University of Warmia and Mazury, Olsztyn, Poland — [4]University of Turku, Finland — [5]DIAS, Dublin, Ireland — [6]Royal Observatory of Belgium, Brussels, Belgium — [7]Polish Academy of Sciences, Warsaw, Poland — [8]ASTRON, Dwingeloo, Netherlands

We present LOFAR observations of an M class flare with intense type III radio bursts. Some isolated burst have a fundamental-harmonic structure, but for most bursts this is not visible due to a rapid succession of bursts. Spectroscopic imaging with LOFAR shows type III bursts as a compact source for a given frequency. The intensity varies with burst evolution, and transient dual-source structures appear. We interpret these as signatures of fundamental and harmonic emission, the latter from a higher location in the corona. Fundamental-harmonic pairs, e.g. fundamental emission at 35 MHz and harmonic emission at 70 MHz, should originate from the same plasma volume. Differences in their positions and intensity variations are expected since radio wave transport effects in the corona, like scattering and refraction, should affect fundamental more than harmonic emission. Analyzing such differences therefore allows for quantifying these effects.

EP 11.8 Thu 15:30 ZHG101

Temperature anisotropy instabilities of solar wind electrons with regularized Kappa-halos resolved with ALPS — •Dustin Schröder[1], Horst Fichtner[1], Marian Lazar[1,2], Daniel Verscharen[3], and Kris Klein[4] — [1]Ruhr-Universität Bochum — [2]Katholieke Universiteit Leuven — [3]University College London — [4]University of Arizona

Space plasmas in various astrophysical setups are often hot & diluted, making them highly susceptible to waves/fluctuations, which are generally self-generated & maintained by kinetic instabilities. In this sense, we have in-situ observational evidence from the solar wind & planetary environments, which reveal not only wave fluctuations at kinetic scales of electrons & protons, but also non-equilibrium distributions of particle velocities. We report on the progress made in achieving a consistent modeling of the instabilities generated by temperature anisotropy, taking example of those induced by anisotropic electrons: whistler & firehose instabilities. The effects of the main electron populations, the quasi-thermal core & the suprathermal halo indicated by the observations, are captured. The low-energy core is bi-Maxwellian, & the halo is described for the first time by a regularized bi-κ-distribution (RKD), which was recently introduced to fix the inconsistencies of standard κ-distributions. In the absence of an analytical RKD dispersion kinetic formalism, the dispersion relation & (in)stability properties are directly solved numerically using the Aribitrary Linear Plasma Solver (ALPS). The results have an increased degree of confidence, considering the successful testing of ALPS on previous results.

EP 12: Sun and Heliosphere V

Time: Thursday 16:15–18:00 Location: ZHG101

Invited Talk EP 12.1 Thu 16:15 ZHG101

The Influence of Intermittent Turbulence on Solar Energetic Particle Transport: Modelling and Observations — •Frederic Effenberger — Ruhr-Universität Bochum

The detailed understanding and ultimately the ability to forecast solar energetic particle (SEP) events is critical in our efforts to mitigate space weather risks. I will discuss current issues in SEP modelling and observations, highlighting the capabilities under development at Ruhr-University Bochum. Of particular interest are coherent features in the solar wind turbulence that can influence particle transport behaviour. Synthetic fields to study particle transport are typically generated from superpositions of Fourier modes with a prescribed power spectrum and uncorrelated random phases, bringing the advantage of covering a wide range of turbulence scales at manageable computational effort. However, almost all of these models to date only account for second-order Gaussian statistics and thus fail to include intermittent features, as observed in more realistic but expensive direct magnetohydrodynamic simulations. We have developed novel methods to account for such shortcomings, including a minimal Lagrangian map approach. We investigate the particle transport properties by solving a large number of particle orbits in these synthetic turbulence realisations and specifically look for non-diffusive regimes and non-standard energy dependences resulting from the intermittency of the generated fields. Applications to SEP transport and acceleration and their connections to recent observations by Parker Solar Probe and Solar Orbiter will be discussed.

EP 12.2 Thu 16:45 ZHG101

Modeling superdiffusive Particle Motion with truncated Lévy Flights* — •Magdalena Litwin[1,2], Sophie Aerdker[1,2], Lukas Merten[1,2], and Horst Fichtner[1,2] — [1]Theoretical Physics IV, Plasma Astroparticle Physics, Faculty for Physics and Astronomy, Ruhr University Bochum, 44780 Bochum, Germany — [2]Ruhr Astroparticle and Plasma Physics Center (RAPP Center), Germany

In the heliosphere, power-law profiles of high-energetic particles at shocks have been observed. These observations point to anomalous, non-Gaussian, transport behavior that might result from intermittent magnetic field structures. Previous studies showed that the power-law distributions can be described by a Lévy flight model. One limitation of such models is that the mean square displacement diverges. In Lévy walk models a spatio-temporal coupling leads to a finite mean-square displacement. We present a similar approach, a truncated Lévy flight model where the mean-square displacement is well-defined. The truncated Lévy flights are simulated with a modified version of the public software framework CRPropa 3.2. The resulting spatial distributions of the new model are compared to those obtained with non-truncated Lévy flight and Lévy walk models. First applications of particle transport at a shock are presented. *supported by SFB1491

EP 12.3 Thu 17:00 ZHG101

Superdiffusive acceleration at heliospheric shocks — •Horst Fichtner[1,2], Sophie Aerdker[1], Frederic Effenberger[1], Lukas Merten[1], and Dominik Walter[1] — [1]Institut fuer Theoretische Physik IV: Ruhr-Universitaet Bochum — [2]Research Department Plasmas with Complex Interactions, Ruhr-Universitaet Bochum

A classical paradigm for the acceleration of energetic particles is the diffusive shock acceleration. For many years this first-order Fermi process was the preferred one to explain the origin of Galactic cosmic rays and of various heliospheric populations, like anomalous cosmic rays or solar energetic particles. In recent years, the evidence has increased, that anomalous transport leading to superdiffusive shock acceleration appears to play a role in the energization of charged particles at shocks. Corresponding numerical simulations have to be based on the solution of fractional partial differential equations, either via finite difference methods or equivalent stochastic differential equations. In the talk both methods will be briefly described, their results for selected cases will compared, and open questions will be discussed. *supported by SFB1491

EP 12.4 Thu 17:15 ZHG101

Modulation of 1 GV protons - comparison of SOHO/EPHIN to AMS-02 fluxes — Bernd Heber[1], •Malte Hörlöck[1], Stefan Jensen[1], Patrick Kühl[1], Lisa Romaneehsen[1], and Holger Sierks[2] — [1]Christian-Albrechts-Universität Kiel, Kiel, D — [2]Max-Planck-Institut für Sonnensystemforschung, Göttingen, D

The Electron Proton Helium INstrument (EPHIN) aboard SOHO is designed to measure high-energy particles and is operating since 1995. It provides energy spectra of protons in the energy range from 4 to about 800 MeV. Above 50 MeV the $\frac{dE}{dx} - \frac{dE}{dx}$- and Bowtie-method is used to determine the energy dependent flux. To validate the measurements, we used published proton fluxes from 2011 to 2019 obtained by the Alpha Magnetic Spectrometer (AMS-02) which is a state-of-the-art particle physics detector designed to study cosmic rays and provides proton fluxes from ≈ 400 MeV to 100 GeV. Here we present the methods and their results that lead to an agreement with AMS-02 within 20% for protons with energies between 400 and 700 MeV. This work received funding from the BMWI (50OC2302,50OC2404) and the EU (101135044 - SPEARHEAD).

EP 12.5 Thu 17:30 ZHG101

Energy spectra of 300 keV to 1 MeV electrons from the SOHO Electron Proton Helium INstrument (EPHIN) — •Stefan Jensen[1], Bernd Heber[1], Alexander Kollhoff[1], Patrick Kühl[1], and Holger Sierks[2] — [1]Institut für Experimentelle und Angewandte Physik, Christian Albrechts-Universität zu Kiel, Germany — [2]Max Planck-Institut für Sonnensystemforschung, Göttingen, Germany

The origins of energetic electrons with energies ranging from a few tens of keV to tens of MeV in the inner heliosphere are manifold. They include Galactic Cosmic Rays, Jovian electrons as well as sporadic Solar Energetic Electron (SEE) events. Their energy spectra provide insights into the acceleration at the source and transport processes in the heliosphere. The SOlar and Heliospheric Observatory (SOHO) was launched December 1995 with the Electron Proton Helium INstrument (EPHIN) measuring electrons from 150 keV to several MeV. However, its measuring capability was reduced due to the failure of two detectors in 1997 and 2017, respectively. Thus from 2017 onwards only two electron channels, one in the range from 150 keV to one MeV and one broad channel that measures between 300 keV and 10 MeV. In this contribution we present a new data product for electron spectra based on the onboard histograms. This data product has the advantage of providing the total energy loss in the first two detectors with good statistics compromising energy resolution and counting statistics.

Using the bow-tie method we were able to derive the flux in several energy channels between 300 keV and about 1 MeV. We present first results and compare them with instruments from other missions.

EP 12.6 Thu 17:45 ZHG101

Refining the GEANT4 model of EPHIN — •Malte Hörlöck[1], Bernd Heber[1], Stefan Jensen[1], Patrick Kühl[1], and Holger Sierks[2] — [1]Christian-Albrechts-Universität, Kiel — [2]Max-Planck-Institut für Sonnensystemforschung, Göttingen

The Electron Proton Helium INstrument (EPHIN) aboard SOHO is designed to measure electrons, protons and Helium. It is operating since 1995. GEANT4 simulations are extensively used to produce response functions needed to obtain primary quantities (like fluxes) from the quantities that EPHIN provides. Starting from an idealized model representing the nominal design of EPHIN and using calibration measurements performed at the Hahn-Meitner-Institut in Berlin, we demonstrate the development of a refined model including dead-layers, more precise detector dimensions and a model representing the SOHO spacecraft. This work received funding from the BMWI (50OC2302,50OC2404) and the EU (101135044 - SPEARHEAD).

EP 13: Astrophysics I

Time: Friday 9:00–10:30 Location: ZHG101

Invited Talk EP 13.1 Fri 9:00 ZHG101

High-Mass X-Ray Binaries: Living Together with a Black Hole — •Lidia Oskinova — Potsdam University, Potsdam

What happens when the life of a massive binary star takes a dramatic turn, and one of its companions collapses into a neutron star or black hole? The answer lies in high-mass X-ray binaries (HMXBs) systems where the transfer of mass from a giant star onto its compact companion generates extraordinary strong X-ray radiation.

HMXBs are among the most enigmatic and fascinating objects in cosmos, serving as natural laboratories for studying fundamental astrophysical processes. In this talk, I will present a holistic view of HMXBs, connecting their properties to the broader story of stellar lifecycles. We will delve into the intricate dynamics between donor stars and their black hole or neutron star companions, with a special focus on the rare and intriguing HMXBs hosting black holes. Recent improvements in understanding of these systems provide fresh insights into their astrophysical significance.

Finally, I will explore HMXB populations across galaxies, illustrating how X-ray observations with modern powerful X-ray telescopes uncover secrets about compact objects and their pivotal role in the Universe.

EP 13.2 Fri 9:30 ZHG101

ComPol - A Compton polarimeter in a Nanosat — •Matthias Meier[1,2], Carlo Fiorini[4], Peter Hinderberger[1,2], Philippe Laurent[3], Martin Losekamm[1,2], Susanne Mertens[1,2], Jonas Schlegel[1,2], Lorenzo Toscano[4], and Michael Willers[1,2] — [1]Excellence Cluster ORIGINS, Garching, Germany — [2]Technical University of Munich, Munich, Germany — [3]Alternative Energies and Atomic Energy Commission, Paris, France — [4]Polytechnic University of Milan, Milan, Italy

It is hardly possible to resolve the geometry of astrophysical compact objects due to their small size. One way to indirectly learn about their structure are polarization measurements. Especially in the hard X-ray range polarization data is still partially missing. Therefore, the aim of the CubeSat mission ComPol is to fill this gap and to improve the physical model of the black hole binary system Cygnus X-1.

The detector system is composed of a Silicon drift detector (SDD) used as a scatterer and a CeBr3 calorimeter to capture the full Compton kinematics. From the measured interaction points and energies it is possible to perform an event-wise reconstruction and infer the polarization of the initial radiation.

The talk will give an overview of the scientific motivation, the underlying physics, the detector setup and its performance. This research is supported by the Excellence Cluster ORIGINS which is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy - EXC-2094-390783311

EP 13.3 Fri 9:45 ZHG101

Newly discovered nebulae around Galactic B-type stars and their origins — •Olga Maryeva[1], Péter Németh[1], Sabina Mammadova[2], Sergey Karpov[3], Michaela Kraus[1], Lydia Cidale[4], and Anahi Granada[5] — [1]Astronomical Institute, Czech Academy of Sciences, Czech Republic — [2]Shamakhy Astrophysical Observatory, Baku, Azerbaijan — [3]Institute of Physics of the Czech Academy of Sciences, Prague, Czech Republic — [4]Instituto de Astrofísica de La Plata, La Plata, Argentina — [5]Universidad Nacional de Río Negro, San Carlos de Bariloche, Argentina

The mass loss in massive stars is an important process that determines their future evolution and affects on circumstellar environment. Besides of the continuous outflow of matter in the form of stellar winds, massive stars undergo sporadic ejections that lead to the formation of circumstellar envelopes. For today it remains unclear at what stage of evolution the first mass ejection occurs and what instabilities lead to it. We present the results of a study of four B-type stars which circumstellar nebulae have recently been found in the archive of the Wide-field Infrared Survey Explorer. Two of our objects PY Gem and HD253659 are Be stars showing emission double peak Hα profiles. The collected spectral and photometric monitoring data showed that HD253659 has strong photometric variability with an amplitude of 0.3 mag in addition to the Hα profile variability. The other two stars HD215575 and BD+141106 have spectra of usual B-type stars on the main sequence. Spectral analysis, numerical modeling, as well as high proper motions argue that these two objects undergone merging in the past.

EP 13.4 Fri 10:00 ZHG101

On the existence and (non-)uniqueness of null points of flows and magnetic fields as prerequisites for the existence of astropauses — •Dieter Nickeler[1], Kuljeet Singh Saddal[1,2], and Rodrigo Meneses[3] — [1]Astronomical Institute AV CR, Ondrejov, Czech Republic — [2]Charles University, Prague, Czech Republic — [3]Universidad de Valparaiso, Chile

The existence of null points of vector fields is prerequisite for the spanning of separating surfaces. Such surfaces guarantee that topologically disjoint field lines of the corresponding vector fields exist on each side of the separatrix. The existence of separatrices allows to define so-called pauses, e.g. magnetopause (a magnetic separatrix) or astropause (like the heliopause). To analyse the structure of fields with null points, we focus on the stationary approximation. Besides the topological perspective, other physical constraints can require the existence of null points.

We investigate the case of a non-monotonous pressure distribution driving stationary counterstreaming MHD flows such as the interstellar medium flows and the outer stellar wind flows. For a purely ideal hydrodynamical problem, and demanding on the regularity of all involved fields and their derivatives, we demonstrate that the existence of an extremum of the thermal or plasma pressure at a certain point in the generic three-dimensional case automatically implies that this point is also a stagnation point (= null point of the plasma flow). An extended analysis is performed for ideal MHD and further for MHD with additional, general non-ideal terms.

EP 13.5 Fri 10:15 ZHG101

3D Resistive MHD Perspectives on the Localized Dynamics at the Apex of an Astropause — •Kuljeet Singh Saddal[1,2], Dieter Nickeler[1], and Rodrigo Meneses[3] — [1]Astronomický ústav AV CR, Ondřejov, Czech Republic — [2]Charles University, Faculty of Mathematics and Physics, Praha, Czech Republic — [3]Universidad de Valparaíso. General Cruz 222, Valparaíso

The dynamical interaction zones where stellar winds collide with the interstellar medium, known as astrospheres, are characterized by complex hydrodynamic (HD) or magnetohydrodynamic (MHD) discontinuities. Central to this interaction is the astropause, a boundary separating stellar wind and interstellar flows, whose structure is governed by fluid flow separatrices. In the MHD framework, the presence of a magnetic null point and a velocity stagnation point near the apex of the astropause is essential. Assuming these points coincide, we derive exact solutions to the resistive MHD equations in three-dimensional space. The topology of the magnetic field and two free parameters describes the nature of these solutions. We identify flows that traverse the magnetic field separatrices, i.e., the fan plane and spine line, potentially enabling the identification of true reconnective solutions. The goal of this analysis is to identify and differentiate reconnective and non-reconnective solutions based on specific criteria. Using these solutions, we calculate dissipation rates and derive thermodynamic properties, such as pressure and temperature, at the apex. This enables the computation of radiance and the generation of synthetic sky maps for comparison with observational data.

EP 14: Astrophysics II

Time: Friday 11:00–12:30 Location: ZHG101

EP 14.1 Fri 11:00 ZHG101

3D radiative MHD simulations of starspots — •Tanay Veer Singh Bhatia, Mayukh Panja, Robert H. Cameron, and Sami K. Solanki — Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany

The contribution of starspots to stellar variability comprises one of the largest sources of uncertainty in detecting and characterizing exoplanets. Existing methods to account for this variability do not take into account the detailed physical nature of starspots. We compute realistic 3D radiative MHD near-surface models of starspots with substantial penumbrae on cool main-sequence stars using the MURaM simulation code. This work is an improvement on the the previous starspot models in a slab geometry. The umbra, penumbra and the quiet star for all starspots are distinct, not only in intensity and temperature, but also in thermodynamic and velocity structure. These models represent a significant step towards modeling contribution of starspots to stellar lightcurves.

EP 14.2 Fri 11:15 ZHG101

Spatio-temporal correlation in incompressible MHD turbulence — •Raquel Mäusle and Wolf-Christian Müller — Technische Universität Berlin, Berlin, Germany

Turbulent flows are ubiquitous on Earth and throughout the universe, playing an important role in many astrophysical plasmas. Three-dimensional magnetohydrodynamic (MHD) turbulence exhibits a direct energy cascade, driven by the nonlinear interaction of colliding Alfvén wave packets. Our aim is to study the temporal and spatial properties of the energy transfer process by computing the spatio-temporal correlation between turbulent fluctuations of various length scales. The fluctuations are measured in direct numerical simulations in the co-moving Quasi-Lagrangian reference frame, which eliminates the large-scale sweeping effect. The single-time correlation between fluctuations parallel and perpendicular to the local magnetic field gives insight into the shape of the turbulent structures, whereas the multi-time correlation allows a measurement of the time scales involved in the cross-scale energy transfer and the propagation of Alfvén wave packets. In both cases, our results show a strong indication of critical balance behavior.

EP 14.3 Fri 11:30 ZHG101

Modeling fast charged particle transport in strong magnetic turbulence — •Jeremiah Lübke[1], Patrick Reichherzer[2], Sophie Aerdker[3], Frederic Effenberger[1,3], Horst Fichtner[3], and Rainer Grauer[1] — [1]Institut für theoretische Physik I, Ruhr-Universität Bochum, 44801 Bochum, Deutschland — [2]Department of Physics, University of Oxford, Oxford OX1 3PU, United Kingdom — [3]Institut für theoretische Physik IV, Ruhr-Universität Bochum, 44801 Bochum, Deutschland

The transport of energetic charged particles in strong magnetic turbulence is a highly complex phenomenon. Inspired by recent work on the role of the fieldline curvature in this problem, we investigate the interplay between pitch-angle scattering and fieldline geometry by means of test particle simulations in isotropic MHD snapshots. We characterize the magnetic field as coherent when its local curvature radius is larger than the current gyroradius of the particle, and find distinct transport behavior in either case. Guided by our observations, we develop stochastic models based on a competition between compound diffusion along coherent fieldlines and diffusive scattering. Finally, we discuss implications on synthetic turbulence models and avenues to a transport theory based on a generalized master equation.

EP 14.4 Fri 11:45 ZHG101

MHD simulations of turbulent galactic outflows — •Jens Kleimann and Horst Fichtner — Theoretische Physik IV, Ruhr-Universität Bochum, Germany

Simulations of the wind-filled halos of starburst galaxies are performed in the framework of magnetohydrodynamics (MHD), suitably extended to track additional turbulence-related quantities. These quantities comprise the turbulent energy density, the cross-helicity, and the turbulent correlation length scale. First, the occurrence of an unexpected large-scale hydrodynamic flow instability, the cause of which can be linked to the galaxy's mass, is described and discussed. The full system of equations is then solved for a typical lower-mass galaxy until a steady state is reached. The talk concludes with an analysis of the resulting turbulent properties within the galactic halo and a quantification of the associated particle diffusion parallel and perpendicular to the large-scale magnetic field.

EP 14.5 Fri 12:00 ZHG101

Relativistic test-particle transport and acceleration in MHD jets — •Patrick Günther, Karl Mannheim, and Sarah M. Wagner — Julius-Maximilians-Universität Würzburg

Extragalactic jets show continuum emission across the entire electromagnetic spectrum and variability on all observed timescales. Modelling this non-thermal emission can be achieved by simultaneously describing the kinetics of relativistic particles and the fluid-dynamical bulk plasma in the jet. We solve a time-dependent transport equation by means of stochastic differential equations, which describes the propagation of particles in the background of a MHD-simulated jet and includes effects such as diffusive shock acceleration and stochastic acceleration. Using this hybrid MHD-kinetic approach, we aim to study the effect of the multiple shocks with varying strengths and obliquities on the resulting non-thermal particle distributions in MHD jet simulations. The time-dependency of the simulation makes the extraction of light curves at any wavelengths possible.

EP 14.6 Fri 12:15 ZHG101

Can We Analytically Predict the Variability of Blazars? — •Vito Aberham and Felix Spanier — Institut für Theoretische Astrophysik, Universität Heidelberg, Albert-Ueberle-Str. 2, 69120 Heidelberg, Germany

Active galactic nuclei (AGN) are known for their variable emission. We apply an evolving two-zone model to their hybrid jets containing both electrons and protons, allowing for the emission of neutrinos. The dominant source of variability, these AGN jets are characterized by the main cooling process triggering the SED's high-energy peak. We choose blazars with proton synchrotron radiation as the predominant emission mechanism for high energies, while electron synchrotron radiation drives the low energy emission. We defer the case of cascades dominating the emission to future work. Including both their acceleration and cooling in the respective zones, we obtain the particle distributions by solving two coupled PDEs while neglecting the effect of second-order Fermi acceleration. We then calculate the photon density, which, combined with the proton distribution, yields the emerging neutrino flux. We infer the according light curves and neutrino fluxes in specific energy bands, enabling comparisons to a wide range of observed blazars. To fully leverage our analytical result's dependency on the free model parameters, we introduce a public tool capable of simulating blazar flares, which allows for rapidly cross-checking numerical simulations at low computational cost. We thus developed the ability to not only predict the variability of any proton-synchrotron dominated blazar analytically but also enhance the quality of simulations.

EP 15: Astrophysics III

Time: Friday 13:30–16:00 Location: ZHG101

Invited Talk EP 15.1 Fri 13:30 ZHG101
Nucleosynthesis of heavy elements in the hot and dense plasmas of explosive astrophysical environments — •Daniel Siegel — Universität Greifswald

Gravitational-wave and multi-messenger astronomy shed light on the astrophysics of black holes and neutron stars and also allow for unique probes of fundamental physics. I will discuss recent results on how the mergers of neutron stars as well as other explosive systems such as the death of massive, rotating stars (collapsars) give rise to the formation of heavy elements in the universe. In particular, I will discuss recent results at the interface of numerical relativity, relativistic astrophysics, neutrino physics as well as nuclear astrophysics, and highlight how multi-messenger astronomy may lead to answers of a 70-year old fundamental question in physics: How does the Universe create its heaviest elements?

EP 15.2 Fri 14:00 ZHG101
Time-dependent modeling of radiative processes in pulsar wind nebulae generated by neutron-star mergers — •Eric Schneider[1], Michael Müller[1], and Daniel Siegel[1,2] — [1]Institute of Physics, University of Greifswald, Greifswald, Germany — [2]Department of Physics, University of Guelph, Guelph, Ontario, Canada

Emission from pulsar wind nebulae (PWNe) and the thermal emission of kilonovae (KN) have traditionally been studied as separate phenomena, associated with distinct astrophysical origins. A pulsar wind nebula is composed of a relativistic leptonic plasma powered by a pulsar typically found in supernova remnants. The leptons cool down through a variety of radiative processes, giving rise to distinct non-thermal emission. A KN is a thermal electromagnetic transient driven by the radioactive decay of neutron-rich nuclei, which are synthesized by the rapid neutron-capture process in the dense plasma outflows from neutron star mergers.

Recent models suggest PWNe may also form in binary neutron star mergers, driven by long-lived remnant neutron stars. These PWNe differ from their supernova counterparts because of their high compactness and high photon densities, requiring new theoretical approaches.

We present a unified model for PWNe evolution and electromagnetic emission, together with a generalized KN model that incorporates the presence of a PWN. We generate a catalog of combined non-thermal and thermal emission to aid interpretation of future merger observations and to constrain properties of merger remnants.

EP 15.3 Fri 14:15 ZHG101
Neutrino-cooled accretion disks around massive black holes and their potential as sites for r-process nucleosynthesis — •Javiera Hernández Morales and Daniel M. Siegel — Institute of Physics, University of Greifswald

The astrophysical origin of about half of the elements heavier than iron, synthesized through rapid neutron-capture (the r-process), is still uncertain. Among proposed sites—neutron-star mergers and collapsars—a common scenario is the formation of a black hole surrounded by an accretion disk. A necessary condition for the r-process to occur in outflows from such disks is a neutron-rich environment, which these disks can achieve through neutrino-cooling. However, the minimum rate at which a black hole needs to accrete to activate this mechanism is still an open question. We employ a one-dimensional, general-relativistic model of accretion disks with weak interactions to explore the parameter space of black-hole mass, accretion rate, and α-viscosity, and study the effect of these parameters on the accretion flow and the presence of neutron-rich material. We find that disks with larger accretion rates reach a lower proton fraction Y_e, with neutron-rich plasma extending over increasingly wider ranges in radii. We show that the characteristic accretion rates that describe the efficiency of cooling, the opaqueness to neutrinos and the trapping of neutrinos in the accretion flow follow power-law relations with black-hole mass and α-viscosity. Our results suggest that disks around black holes with masses ranging from $\sim 3M_\odot$ to $\sim 10^3 M_\odot$ could launch neutron-rich outflows and thus be possible sites for the nucleosynthesis of the heaviest elements in the Universe.

EP 15.4 Fri 14:30 ZHG101
Ignition of weak interactions and r-process outflows in massive, 'super-collapsar' accretion disks — •Aman Agarwal[1] and Daniel Siegel[1,2] — [1]Institute of Physics, University of Greifswald, D-17489 Greifswald, Germany — [2]Department of Physics, University of Guelph, Guelph, Ontario, Canada, N1G 2W1

The core collapse of rapidly rotating massive ($\sim 10M_\odot$) stars ("collapsars") and the resulting hyperaccreting black holes represent a leading model for the central engines of long-duration gamma-ray bursts (GRBs) and promising sources of neutron-rich plasma outflows for r-process nucleosynthesis. We perform three-dimensional general-relativistic magnetohydrodynamics simulations to explore the neutronization of accretion flows from progenitors with masses above the pair-instability mass gap to the regime of massive PopIII stars (black-hole mass range $M_\bullet \sim 80 - 1000\ M_\odot$). We find that neutron-rich accretion flows develop above an "ignition" accretion rate $\dot{M}_{\rm ign}$, which, in good agreement with analytical estimates, scales as $\dot{M}_{\rm ign} \propto M_\bullet^{4/3} \alpha_{\rm eff}^{5/3}$ up to $M_\bullet \sim 1000 M_\odot$, with $\alpha_{\rm eff}$ being the effective Shakura-Sunyaev disk viscosity. We discuss the implications of very early r-process enrichment through such astrophysical events in the light of recent detections of massive stars by the James Webb Space Telescope and reflect upon their potential as multi-messenger sources of both electromagnetic ("super-kilonovae") and gravitational waves for third-generation gravitational-wave detectors.

EP 15.5 Fri 14:45 ZHG101
Signatures of Exploding Supermassive PopIII Stars at High Redshift — •Cédric Jockel — Max Planck Institute for Gravitational Physics, Potsdam, Germany

Recently, supermassive black holes (SMBHs) of $\sim$ 100 million solar-masses have been discovered at high redshifts of $z \sim 9 - 11$. These large masses so early in the universes history pose severe challenges to our understanding of SMBH formation. One possible formation channel is the direct collapse of rapidly accreting PopIII stars that form in large collapsing halos of primordial gas and grow up to a million solar masses. Our recent studies and also work by other groups show that they eventually collapse and produce powerful supernova-like explosions of 10^{55} erg that last over 10 years. Modelling the observational signatures and prospects of their explosions will give us crucial insight on the early stages of SMBH formation. In this talk, I present our recent work on the observability of these supermassive star explosions including the computation of the luminosity, photometry and colour evolution. In our model, we study the scenario where massive ejecta are released during the collapse and explosion and interact with the surrounding dense cloud via shocks. These shock interactions power emissions of up to $\sim 10^{45-47}$ erg/s in the source frame and lead to easily observable signals in JWST and EUCLID. Due to the long explosion timescale of over 10-15 years, the transients will be observed over a period of a few hundred years due to redshift and might be confused photometrically with persistent high-redshift sources such as little red dots.

EP 15.6 Fri 15:00 ZHG101
Beobachtungskampagnen und theoretische Modellierung von Lichtkurven verschmelzender Schwarzer Löcher — •Julian Sommer — Ludwig-Maximilians-Universität München, München, Deutschland

Schwarze Löcher mit Massen von mehreren Dutzend bis Hunderten Sonnenmassen werden vorwiegend in den Regionen aktiver Galaxienkerne, genauer gesagt in den Akkretionsscheiben supermassiver Schwarzer Löcher, vermutet. Die Interaktion des Verschmelzungsprodukts mit dem umliegenden Gas kann zu elektromagnetischen Signaturen führen, die sich in Form von Flares äußern. Die Dauer eines solchen Flares kann sich über Tage bis Wochen erstrecken und lässt sich als Lichtkurve beschreiben. In diesem Vortrag werden erste Ergebnisse der theoretischen Modellierung solcher Lichtkurven vorgestellt und mit unseren Beobachtungen verglichen, um das Verhältnis zwischen Theorie und Praxis zu analysieren. Unsere Beobachtungskampagnen zu Gravitationswellendetektionen durch LIGO/Virgo/KAGRA werden mit dem 2,1-Meter-Wendelstein-Teleskop durchgeführt, das sowohl den 3KK-Imager als auch den Wide-Field-Imager nutzt.

EP 15.7 Fri 15:15 ZHG101
Probing the effects of magnetic fields on ultra-high energy

cosmic ray arrival directions at the Pierre Auger Observatory — •Berenika Čermáková for the Pierre-Auger-Collaboration — Karlsruhe Institute for Technology, Karlsruhe, Germany

When ultra-high-energy cosmic rays (UHECRs) travel from sources to Earth, they are deflected by extragalactic and galactic magnetic fields. Since the deflection depends on the charge of the nuclei, UHECRs with very high magnetic rigidity propagate almost ballistically. Consequently, when detected on Earth, the arrival directions point near their origin. Hence, backtracking the high-rigidity UHECRs could set a limit on different source classes.

However, indirect detection of UHECRs poses challenges in obtaining information about their energy and mass simultaneously. Machine learning-based mass estimators show the potential to improve the reconstruction of mass-sensitive variables, such as the depth of the shower maximum.

In this contribution, we investigate the effect of the galactic magnetic field on the propagation of the UHECRs using neural network-based mass estimators. We test different scenarios of source distributions. In particular, we present the developed methodology to test the hypothesis that sources follow the distribution of matter in space, hence the Supergalactic plane. We use data from the Pierre Auger Observatory.

EP 15.8 Fri 15:30 ZHG101

Precise Reconstruction of Neutrino Event Energy Using Deep Learning — •Severin Magel, Chiara Bellenghi, Elena Manao, and Rasmus Ørsøe for the IceCube-Collaboration — Technical University of Munich, TUM School of Natural Sciences, Department of Physics, James-Franck-Straße 1, D-85748 Garching bei München, Germany

The first ever 5σ detection of an astrophysical neutrino source has long been chased by neutrino telescopes like IceCube and KM3NeT. Achieving a high statistical significance in detecting these sources is partially limited by the precision of variable reconstructions for the incoming neutrino direction and energy. We investigate the potential of state-of-the-art deep learning architectures like Graph Neural Networks (GNN) and transformers to improve classical algorithms and obtain a more precise neutrino energy prediction. We force the model to recognise general patterns in the detector response by training it on all signatures left in the detector by the different neutrino interaction channels. This pre-trained architecture is then fine-tuned for the reconstruction of specific neutrino events that are eventually used in various analyses not limited to the search for an astrophysical neutrino sources. In this presentation, I will outline the technical challenges and the physics-oriented results from these efforts.

EP 15.9 Fri 15:45 ZHG101

Simulation-based inference has its own Dodelson-Schneider effect (but it knows that it does) — •Jed Homer[1,2], Oliver Friedrich[1,2,3], and Daniel Gruen[1,2,3] — [1]University Observatory, Faculty of Physics, Ludwig-Maximilians-Universität, Scheinerstr. 1, 81677 Munich, German — [2]Munich Center for Machine Learning (MCML) — [3]Excellence Cluster ORIGINS, Boltzmannstr. 2, 85748 Garching, Deutschland.

Making inferences about physical properties of the Universe requires knowledge of the data likelihood. A Gaussian distribution is commonly assumed with a covariance matrix estimated from a set of simulations. The noise in such estimates causes two problems: it distorts the parameter contours, and it adds scatter to the location of those contours. For non-Gaussian likelihoods, an approximation may be derived via Simulation-Based Inference (SBI). It is often implicitly assumed that parameter constraints from SBI analyses are not affected by the same problems as parameter estimation, with a covariance matrix estimated from simulations. We investigate whether SBI suffers from effects similar to those of covariance estimation in Gaussian likelihoods. SBI suffers an inflation of posterior variance that is equal or greater than the analytical result in covariance estimation for Gaussian likelihoods for the same number of simulations. The assumption that SBI requires a smaller number of simulations than covariance estimation for a Gaussian likelihood analysis is inaccurate. Despite these issues, we show that SBI correctly draws the true posterior contour given enough simulations.