Extraterrestrial Physics Division
Fachverband Extraterrestrische Physik (EP)

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Overview of Invited Talks and Sessions

(Lecture hall EP-H1)

Plenary and Prize Talks related to EP

SYAW 1.2	Wed	14:40–15:10	Audimax	**Astronomy at Highest Angular Resolution - Adaptive Optics, Interferometry and Black Holes** — •Frank Eisenhauer
PV VIII	Thu	9:45–10:30	Audimax	**The Sun as a source of high-energy particles** — •Rami Vainio

Special topic day T/EP: Astroparticles – From the source to the detector

EP 8.1–8.3	Thu	11:00–12:30	T-H15	**Astroparticles: Invited talks (joint session T/EP)**
EP 10.1–10.4	Thu	14:00–15:40	T-H15	**Astroparticles: Invited topical talks (joint session T/EP)**
EP 11.1–11.9	Thu	16:15–18:30	EP-H1	**Astroparticles: From the source to the detector (joint session EP/T)**

Invited Talks

EP 1.1	Mon	14:00–14:30	EP-H1	**Asteroseismology of red-giant stars** — •Saskia Hekker
EP 2.3	Mon	16:45–17:15	EP-H1	**Cloudy with a hint of magnetic fields** — •Ludmila Carone
EP 3.1	Tue	11:00–11:30	EP-H1	**A new era of Venus exploration - seen Venus in a new light** — •Jörn Helbert, Melinda Darby Dyar, Giulia Alemanno, Alessandro Maturilli, Nils Müller, Doris Breuer, VEM on VERTIAS team, VenSpec on Envision team
EP 4.1	Tue	14:00–14:30	EP-H1	**Exploration of the Jupiter system with a small submillimetre wave telescope onboard the JUICE satellite** — •Paul Hartogh
EP 5.1	Tue	16:15–16:45	EP-H1	**Investigating Earth's atmosphere and ionosphere from space: How GNSS radio occultation measurements contribute to monitor the atmosphere in a high spatial resolution** — •Christina Arras, Ankur Kepkar, Jens Wickert
EP 5.5	Tue	17:30–18:00	EP-H1	**Solar extreme events and their impact on the middle atmosphere** — •Thomas Reddmann, Monali Borthakur, Miriam Sinnhuber, Ilya Usoskin, Jan-Maik Wissing
EP 6.1	Wed	11:00–11:30	EP-H1	**Three-dimensional topology-driven magnetic reconnection** — •Raquel Mäusle, Jean-Mathieu Teissier, Wolf-Christian Müller
EP 12.1	Fri	11:00–11:30	EP-H1	**Linking Solar Eruptions and Energetic Particles through Observations and Modeling** — •Frederic Effenberger
EP 12.4	Fri	12:00–12:30	EP-H1	**Solar Orbiter: two years of operations and first results** — •Frederic Schuller, Alexander Warmuth, Gottfried Mann

Invited Talks of the joint symposium SMuK Dissertation Prize 2022 2022 (SYMD)

See SYMD for the full program of the symposium.

SYMD 1.1	Mon	14:00–14:25	Audimax	**Timeless Quantum Mechanics and the Early Universe** — •Leonardo Chataigner
SYMD 1.2	Mon	14:25–14:50	Audimax	**First tritium β-decay spectrum recorded with Cyclotron Radiation Emission Spectroscopy (CRES)** — •Christine Claessens
SYMD 1.3	Mon	14:50–15:15	Audimax	**Watching the top quark mass run - for the first time!** — •Matteo M. Defranchis, Katerina Lipka, Sven-Olaf Moch
SYMD 1.4	Mon	15:15–15:40	Audimax	**Towards beam-quality-preserving plasma accelerators: On the precision tuning of the wakefield** — •Sarah Schröder

Invited Talks of the joint Awards Symposium (SYAW)

See SYAW for the full program of the symposium.

SYAW 1.1	Wed	14:10–14:40	Audimax	**Wie überprüft man die Ziele der Lehramtsausbildung Physik?** — •Horst Schecker
SYAW 1.2	Wed	14:40–15:10	Audimax	**Astronomy at Highest Angular Resolution - Adaptive Optics, Interferometry and Black Holes** — •Frank Eisenhauer
SYAW 1.3	Wed	15:10–15:40	Audimax	**Turbulence in one dimension** — •Alexander M. Polyakov

Sessions

EP 1.1–1.6	Mon	14:00–15:45	EP-H1	**Astrophysics**
EP 2.1–2.9	Mon	16:15–18:45	EP-H1	**Astrophysics / Exoplanets and Astrobiology**
EP 3.1–3.7	Tue	11:00–13:00	EP-H1	**Planets and Small bodies**
EP 4.1–4.6	Tue	14:00–15:35	EP-H1	**Planets and Small bodies**
EP 5.1–5.8	Tue	16:15–18:45	EP-H1	**Near Earth Space**
EP 6.1–6.8	Wed	11:00–13:15	EP-H1	**Astrophysics**
EP 7.1–7.11	Wed	16:15–18:50	EP-H1	**Astrophysics**
EP 8.1–8.3	Thu	11:00–12:30	T-H15	**Astroparticles: Invited talks (joint session T/EP)**
EP 9	Thu	12:45–13:45	EP-MV	**Mitgliederversammlung Extraterrestrische Physik**
EP 10.1–10.4	Thu	14:00–15:40	T-H15	**Astroparticles: Invited topical talks (joint session T/EP)**
EP 11.1–11.9	Thu	16:15–18:30	EP-H1	**Astroparticles: From the source to the detector (joint session EP/T)**
EP 12.1–12.11	Fri	11:00–14:00	EP-H1	**Sun and Heliosphere**

Annual General Meeting of the Extraterrestial Physics Division

Thursday 12:45–13:45 EP-MV

EP 1: Astrophysics

Time: Monday 14:00–15:45 Location: EP-H1

Invited Talk EP 1.1 Mon 14:00 EP-H1

Asteroseismology of red-giant stars — •Saskia Hekker — Centre for Astronomy (ZAH/LSW), Heidelberg University — Heidelberg Institute for Theoretical Studies (HITS) — Stellar Astrophysics Centre, Aarhus, Denmark

Over the past decades we experienced a revolution in asteroseismology of red-giant stars. In this talk, I will discuss this revolution and first insights gained from asteroseismology into the stellar structure of red-giant stars.

EP 1.2 Mon 14:30 EP-H1

Finite time singularities and their relations to eruptive stellar mass loss events — •Dieter Nickeler and Michaela Kraus — Astronomical Institute, Czech Academy of Sciences, Ondrejov, Czech Republic

In recent years rings, spiral and arc structures have been detected around massive stars with strong stellar winds. These structures are proposed to be a result of stellar mass ejections. Taking a (fast) stationary stellar wind as initial condition, the time-dependent amplitude modulation is analyzed with respect to eventually occurring finite-time instabilities. These so called blow-up solutions can be interpreted as non-linear instabilities in the stellar wind, leading to eruptive mass loss of the star. We analyze under which circumstances such blow-up solutions can exist.

EP 1.3 Mon 14:45 EP-H1

Molecular environment of the yellow hypergiant HD 269953 — •Michaela Kraus[1], Maria Laura Arias[2], and Lydia Cidale[2] — [1]Astronomical Institute, Czech Academy of Sciences, Ondrejov, Czech Republic — [2]Instituto de Astrofisica de La Plata, CONICET-UNLP, Argentina

Yellow hypergiants are massive stars, most likely in post-red supergiant evolutionary state. Stars in this phase can undergo multiple outbursts, and the ejected material might enshroud the stars in gaseous and dusty shells or envelopes. The object HD 269953 has been suggested to be a candidate yellow hypergiant. Although no historic outburst has been reported for that object, its environment hosts a substantial amount of warm CO gas. To unveil the dynamics within the molecular gas we obtained a high-resolution (R $\sim$ 45 000) K-band spectrum of HD 269953 with IGRINS at GEMINI-South. We find that the spectrum is rich in emission features. In particular, we detect emission from the ^{12}CO and ^{13}CO molecular bands. The latter are strongly enriched, in agreement with the hypothesis that the environment contains processed matter that has been released from an evolved object. Moreover, we identified emission of hot water vapor, which is, to our knowledge, the first detection of water in the vicinity of an evolved massive star. We will present first results from our analysis of the circumstellar molecular gas and discuss scenario for its origin.

EP 1.4 Mon 15:00 EP-H1

Kilonovae, gamma-ray bursts, and heavy elements from neutron star mergers — •Oliver Just[1], Andreas Bauswein[1], Thomas Janka[2], Stephane Goriely[3], Ina Kullmann[3], Shigehiro Nagataki[4], Hirotaka Ito[4], and Christine Collins[1] — [1]GSI, Darmstadt, Germany — [2]MPA, Garching, Germany — [3]ULB, Brussels, Belgium — [4]RIKEN, Tokyo, Japan

The collision of two neutron stars, which was first observed in 2017, is one of the most luminous astrophysical explosions, in which not only electromagnetic radiation from radio to gamma-ray frequencies is emitted, but also huge amounts of energy in the form of neutrinos and gravitational waves. In order to decipher these multi-messenger events, e.g. for inferring the mass and composition of the material thrown out in the course of such a merger, one needs to build detailed theoretical models of the processes that lead to matter ejection and the emission of radiation. In this talk I will present our recent efforts to model the merger and its remnant using multi-dimensional hydrodynamics simulations including the transport of neutrinos. Moreover, I will outline how these simulations were used to predict the optical/near infrared signal, called kilonova, the flash of gamma-radiation, called short gamma-ray burst, as well as the amount of heavy elements, such as Gold, produced in the ejecta by means of the rapid neutron-capture (or r-) nucleosynthesis process.

EP 1.5 Mon 15:15 EP-H1

Core-Collapse Simulations of Very Massive Star: Gravitational Collapse, Black-hole Formation, and Beyond — •Ninoy Rahman — GSI Helmholtz Centre for Heavy Ion Research

We investigate the final gravitational collapse of rotating and non-rotating pulsational pair-instability supernova progenitors with zero-age-main-sequence masses of 60, 80, and 115 $M_\odot$ and iron cores between 2.37 $M_\odot$ and 2.72 $M_\odot$ by 2D (axi-symmetric) hydrodynamics simulations. Using the general relativistic NADA-FLD code with neutrino transport allows us to follow the evolution beyond the moment when the transiently forming neutron star (NS) collapses to a black hole (BH), which happens in all cases. Because of high neutrino luminosities and mean energies, neutrino heating leads to shock revival before BH formation in all cases except in the rapidly rotating 60 $M_\odot$ model, where centrifugal effects support a higher NS mass but reduce the neutrino-heating rate by roughly a factor of two compared to the non-rotating counterpart. After BH formation the neutrino luminosities drop steeply but continue on a 1–2 orders of magnitude lower level for several 100 ms because of aspherical accretion of neutrino and shock-heated matter, before the ultimately spherical collapse of the outer progenitor shells suppresses the neutrino emission to negligible values. In all shock-reviving models BH accretion swallows the entire neutrino-heated matter and the diagnostic explosion energies decrease to zero within a few seconds latest. Nevertheless, the shock or a sonic pulse move outward and may trigger mass loss, which we estimate by long-time simulations with the Prometheus code.

EP 1.6 Mon 15:30 EP-H1

Modeling disk fragmentation and multiplicity in massive star formation — •Rolf Kuiper[1] and André Oliva[2] — [1]Universität Heidelberg — [2]Universität Tübingen

There is growing evidence that massive stars grow by disk accretion in a similar way to their low-mass counterparts. Early in evolution, these disks can achieve masses that are comparable to the current stellar mass, and therefore the forming disks are highly susceptible to gravitational fragmentation. We investigate the formation and early evolution of an accretion disk around a forming massive protostar, focussing on its fragmentation physics.

We used a grid-based, self-gravity radiation hydrodynamics code including a sub-grid module for stellar evolution and dust evolution. We purposely do not use a sub-grid module for fragmentation such as sink particles to allow for all paths of fragment formation and destruction, but instead we keep the spatial grid resolution high enough to properly resolve the physical length scales of the problem, namely the pressure scale height and Jeans length of the disk.

The cloud collapses and a massive (proto)star is formed in its center surrounded by a fragmenting Keplerian-like accretion disk with spiral arms. The fragments have masses of ~1 Msol, and their continuous interactions with the disk, spiral arms, and other fragments result in eccentric orbits. Fragments form hydrostatic cores surrounded by secondary disks with spiral arms that also produce new fragments. Based on this, we study the multiplicity from spectroscopic multiples to companions at distances at 1000 au.

EP 2: Astrophysics / Exoplanets and Astrobiology

Time: Monday 16:15–18:45 Location: EP-H1

EP 2.1 Mon 16:15 EP-H1

Cross-matching Low Frequency Array (LOFAR) Sources — •Lukas Böhme — Fakultät für Physik, Universität Bielefeld, Deutschland

Multi-frequency studies of the radio sky provide insight into the nature of the observed objects. To do so, I cross-match resolved and unresolved radio sources at different frequencies and angular resolutions.

The combination of several radio bands from the Low Frequency Array (LOFAR) and other radio telescopes with multi-frequency optical and infrared data allows for photometric redshift estimates, not only for LOFAR Two-metre Sky Survey (LoTSS) sources, but also for lower resolution LOFAR LBA Sky Survey (LoLSS) and NRAO VLA Sky Survey (NVSS) sources.

I present a new cross-matching algorithm incorporating the radio source extensions and apply it to the catalogues from LoLSS-PR, LoTSS-DR1, LoTSS-DR2 (LOFAR) and NVSS (VLA).

I study the number of components of LoLSS radio sources and their spectral properties. I find an average spectral index of $\alpha = -0.77 \pm 0.17$ for sources matched in all surveys. This spectral index is flux density independent above $S_{1400} = 30$ mJy and appears to be redshift independent.

EP 2.2 Mon 16:30 EP-H1

2-Kanal - Kohonenkarten zur Klassifizierung von Radioquellen und Identifizierung von optischen Host-Galaxien — •Schwarz Kilian[1], Stevens Simon[1], Mah Zhee Kein Jeremy[1], El-Beit Shawish Sara[1], Farjoud Masouleh Negar[1], Imhof Dennis[1], Rapp Stefan[1] und Hoeft Matthias[2] — [1]Hochschule Darmstadt, Haardtring 100, 64295 Darmstadt — [2]Thüringer Landessternwarte, Sternwarte 5, 07778 Tautenburg

Aufgrund der großen Datenmengen durch aktuelle Himmelsdurchmusterungen gewinnt die Klassifikation mit Hilfe von Methoden des maschinellen Lernens an Bedeutung. Für die ausgedehnten Quellen in der ersten Veröffentlichung von Daten des LOFAR Two-Metre Sky Survey (LoTSS) hat sich die automatische Gruppierung der Quellmorphologien mit Hilfe der Self-Organising-Maps (SOMs) als sehr leistungsvoll erwiesen [Mostert et. al 2020, Astronomy & Astrophysics]. In diesem Beitrag wird gezeigt, wie diese Methode weiterentwickelt werden kann, um die morphologische Klassifikation von Radioquellen zu verbessern und die zugehörigen Wirtsgalaxien in optischen Karten [Chambers et. al 2019, arXiv] zu identifizieren. Hierzu werden 2-Kanal-Kohonenkarten mit Hilfe der PINK-Software [Polsterer et. al 2016, 24th European Symposium on Artificial Neural Networks] trainiert und anschließend analysiert. Durch das Setzen eines Begrenzungsrahmens wird die Anzahl der möglichen zugehörigen Wirtsgalaxien erheblich eingeschränkt. In weiteren Schritten werden andere Eigenschaften der Quellen, z.B. Rotverschiebung, zusätzlich in dem Lernverfahren berücksichtigt. Die aktuellen Ergebnisse werden präsentiert.

Invited Talk EP 2.3 Mon 16:45 EP-H1

Cloudy with a hint of magnetic fields — •Ludmila Carone — St Andrews University, St Andrews, UK — Max Planck Institute for Astronomy, Heidelberg, D

In this review talk, I will present the state of the art of numerical models of exoplanet atmospheres. I will show why it is important to consider that exoplanets are three dimensional objects that can change their local observed atmosperic gas phase composition (C/O ratio) via cloud formation and disequilibrium chemistry. Since C/O ratios are used as proxies for exoplanet formation it is important that 3D processes are incorporated in the interpretation of upcoming detailed observations with next generation space telescopes: i.e. the James Webb Space Telescope, ARIEL and also PLATO. Last but not least, tackling magnetic fields interaction and how they impact observable properties in exoplanet atmospheres is an ongoing numerical challenge.

EP 2.4 Mon 17:15 EP-H1

Gap in Solar System's Proto Planetary Disk Likely Confirm Features in the Distribution of Exoplanet Semi-Major Axes — •Stuart F. Taylor — SETI Affiliate, Mountain View, CA USA — Participation Worldscope, Hong Kong

The recent discovery of a gap dividing the solar system's protoplanetary disk (SS's PPD) may be a confirmation of the peak-gap-peak (PGP) feature in the distribution of semi-major axes of exoplanets hosted by stars most like the sun. This PGP feature was published before the SS PPD gap was presented. It has long been thought that PPDs form with separate inner and outer disks separated by a gap, but seeing this structure in the distribution of exoplanet semi-major axes is unexpected due to how it is thought that primordial features are erased by subsequent planet migration. The solar system gap is reported to be closer than 3 AU, while the PGP feature's gap extends from 1.5 to 1.9 AU for planets of solar mass stars. The two results taken together suggest that planets of stars that are similar to the sun or with higher metallicity may generally start their evolution with a gap in this range, likely associated with a snow line. We are now finding that the semi-major axis of this feature appears to scale with the square root of stellar mass. We also propose that the study of planetary system architectures and demographics be organized in the form of a new additional section of an exoplanet catalog, which would include results on exoplanet occurrence distributions and findings of features and correlations among exoplanet parameters.

EP 2.5 Mon 17:30 EP-H1

Composition of super-Earths, super-Mercuries, and their host stars — •Vardan Adibekyan — nstituto de Astrofísica e Ciências do Espaço (IA)

Because of their common origin, it is expected (or assumed) that the composition of planet building blocks should (to a first order) correlate with stellar atmospheric composition, especially for refractory elements. In fact, information on the relative abundance of refractory and major rock-forming elements such as Fe, Mg, Si are commonly used to improve interior estimates for terrestrial planets (e.g. Dorn et al. 2015; Unterborn et al. 2016) and has even been used to estimate planet composition in different galactic populations (Santos et al. 2017). However, there is no direct observational evidence for the aforementioned expectation/assumption and was even recently questioned by Plotnykov & Valencia (2020). By using the largest possible sample of precisely characterized low-mass planets and their host stars, we show that the composition of the planet building blocks indeed correlates with the properties of the rocky planets. We also find that on average the iron-mass fraction of planets is higher than that of the primordial values, owing to the disk-chemistry and planet formation processes. This result can bring important implications for the future modeling of exoplanet composition.

EP 2.6 Mon 17:45 EP-H1

Planetary interiors via Love-number determined from radial velocities — •Lia Marta Bernabò and Szilárd Csizmadia — DLR Berlin, Institut für Planetenforschung (Deutsches Zentrum für Luft- und Raumfahrt) - Rutherfordstr. 2, 12489 Berlin

We study the inner structure of planets by determining the Love numbers kn and hn (Love, 1911), which describes the susceptibility of their shape to change in response to a tidal and rotational potential. The second degree Love number k2 is highly sensitive to the thickness of the interior layers and rheology of the planet and it is proportional to the concentration of mass towards the centre of the planet, therefore it is used to infer the internal structure of the body. We will present the method how to analyze the radial velocity curve in presence of apsidal motion caused by tidal interaction between the star and the planet, and by general relativity. The former one can be linked to the Love-number k2 (Kopal, 1959) which constrains the planetary interior as a third measurable parameter beyond the mass and radius (Baumeister et al., 2020). We also study the effect of the rotationally and tidally distorted stellar shape on the radial velocity curves. This causes a distortion on the RV-shape as well, and leads to the presence of an apparent eccentric orbit in the RV-curve. We show that the correct estimate of this effect must be taken into account and some other studies overestimated its amplitude and significance. Finally, we show our first results when we applied our method to real systems.

EP 2.7 Mon 18:00 EP-H1

Stellar Flares and Habitable(?) Worlds from the TESS Primary Mission — •Maximilian N. Günther — European Space Agency (ESA), European Space Research and Technology Centre (ESTEC), Keplerlaan 1, 2201 AZ Noordwijk, Netherlands

On our search for habitable worlds, we have to account for explosive stellar flaring and coronal mass ejections (CMEs) impacting exoplanets. These stellar outbursts are a double-edged sword. On the one hand, flares and CMEs are capable of stripping off atmospheres and extinguishing existing biology. On the other hand, flares might be the (only) means to deliver the trigger energy for prebiotic chemistry and initiate life. This talk will highlight our study of all stellar flares from the TESS primary mission, driven by a convolutional neural network. I will discuss our new insights on flaring as a function of stellar type, age, rotation, spot coverage, and other factors. Most importantly, I will link our findings to prebiotic chemistry and ozone sterilisation, identifying which worlds might lie in the sweet spot between too much and too little flaring. With future extended missions and increased coverage, flare studies and new exoplanet discoveries will ultimately aid in defining criteria for habitability.

EP 2.8 Mon 18:15 EP-H1

INCREASE - An updated model suite to study the INfluence of Cosmic Rays on Exoplanetary AtmoSpherEs — •Konstantin Herbst[1], J. Lee Grenfell[2], Miriam Sinnhuber[3], and Fabian Wunderlich[2] — [1]Institut für Experimentelle and Angewandte Physik, Christian-Albrechts-Universität zu Kiel, 24118 Kiel — [2]Institut für Planetenforschung, Deutsches Zentrum für Luft- und Raumfahrt, 12489 Berlin — [3]Institut für Meteorologie und Klimaforschung, Karlsruher Institut für Technologie, 77344 Eggenstein-Leopoldshafen

Much remains to be explored when it comes to the diversity of exoplanetary atmospheres, much remains to be explored. For a few selected objects such as Proxima Centauri b, first observations of the atmosphere have already been achieved. At the same time, much more information is expected soon with the help of JWST launched in December 2021. However, to interpret existing and upcoming observations, model studies of planetary atmospheres that account for various processes - e.g., atmospheric escape, outgassing, climate, photochemistry, and the physics of air showers - are necessary. Here, we present our unique model suite INCREASE investigating the impact of cosmic rays on diverse exoplanetary atmospheres and their habitability.

EP 2.9 Mon 18:30 EP-H1

Viruses first? — •Karin Moelling — Inst. med. Mikrobiologie, Universität Zürich, Gloriastr 30, 8006 Zürich, Schweiz — Max Planck Institut Mol.Gen. Ihnestr 73 14195 berlin Deutschland

The discovery of exoplanets within putative habitable zones and spaceships to Mars and Eraly Earth raise interest in the origin of life. Could viruses play a role at the beginning of life on Earth and elsewhere? Viruses are the most successful species on Earth in every habitat. Contemporary viruses reflect evolution ranging from the early RNA world to the present DNA-protein world. Earliest replicating and evolving entities are enzymatic non-coding RNA molecules, ribozymes or viroids, fulfilling criteria of life. RNA is till today a dominating molecule in almost all aspects of life, generating novel information as driver of evolution. The whole Universe contains essential building blocks of life H,O,C,N,P. Water may be essential. Meteorites teach us about aminoaicds. The diversity of survival mechanism are demonstrated by extremophilic archaea, which developed indivdual survival metabolisms depending on extreme living conditonas as extrempohils. Autonomy of early life forms may have been given up by energy-saving parasitic life forms today.(Moelling and Breocker,2019, doi: 10.3389/fmicb.2019.0052310.3389/fmicb.2019.00523)

EP 3: Planets and Small bodies

Time: Tuesday 11:00–13:00 Location: EP-H1

Invited Talk EP 3.1 Tue 11:00 EP-H1

A new era of Venus exploration - seen Venus in a new light — •Jörn Helbert[1], Melinda Darby Dyar[2], Giulia Alemanno[1], Alessandro Maturilli[1], Nils Müller[1], Doris Breuer[1], VEM on VERTIAS team[1], and VenSpec on Envision team[1] — [1]Institute for Planetary Research, DLR, Berlin, Germany — [2]Mount Holyoke College, USA

Venus is our next-door planet. It is almost identical in size to Earth and yet we know so little about it. Recently three new mission have been selected to study Venus - the ESA EnVision and the NASA VERITAS and DAVINCI missions. The new interest in Venus has partly come through discussions with the exoplanet community about why their models always lean towards Earth-like planets. They have asked for fundamental parameters for Venus to improve their models, like the surface composition of Venus, and we just do not have the answers currently. This led to the realisation that we need to find out more about this planet that has evolved in such a different way from the Earth in order to understand how habitable planets evolve in general.

All three recently selected Venus missions include in their payload instruments focused on the 1 micron region. The NASA VERITAS and ESA EnVision missions use the DLR build Venus Emissivity Mapper (VEM) as a multi-spectral imaging system. The DAVINCI mission has a 1 micron descent imager. These new instruments have been made possible in part by a dedicated effort to set up a new Venus high temperature spectroscopy laboratory at DLR to routinely obtain VNIR emissivity spectra at relevant Venus surface temperatures.

EP 3.2 Tue 11:30 EP-H1

The impact of large solar particle events on the chemical composition of the Martian atmosphere — •Miriam Sinnhuber[1], John Lee Grenfell[2], Konstantin Herbst[3], and Fabian Wunderlich[2] — [1]Karlsruher Institute für Technologie, Karlsruhe, Germany — [2]DLR Institut für Planetenforschung, Berlin, Germany — [3]Universität Kiel, Kiel, Germany

Large solar coronal mass ejections are known to have a large impact on the chemical composition of the high-latitude atmosphere of Earth. Collision of the incident protons and resulting secondary electrons with the most abundant atmospheric constituents leads to dissociation, ionization, and dissociative ionization of these substances; in the Earth's atmosphere, these are N_2 and O_2, and the main products are nitrogen radicals and nitrogen oxides (NOx: N, NO, NO_2) as well as hydrogen oxides (HOx: OH, HO_2) from the uptake of water vapor into large cluster ions. Both NOx and HOx species contribute to catalytic ozone loss, and very rapid loss of ozone in the terrestrial polar stratosphere and mesosphere is well-documented. However, not much is known about the impact of these events on other planets. Here, we present results from model experiments for the atmosphere of Mars, considering three different solar particle events: a ground-level event (1956), the Carrington white light flare (1859), and one of the largest ground-level events found in the paleo-record so far, the AD774/775 event. The analysis focuses on the different responses of the thin Martian atmosphere with its low amounts of nitrogen and high CO_2 mixing ratio.

EP 3.3 Tue 11:45 EP-H1

The interaction of the Martian with the solar wind as observed by MAVEN — •Lukas Maes and Markus Fraenz — Max Planck Institute for Solar System Research, Göttingen, Germany

The Mars Atmosphere and Volatile EvolutioN (MAVEN) mission was launched in 2013 to study the atmosphere and ionosphere of Mars, its interaction with the solar wind, and the consequences for the erosion of the Martian atmosphere. With a comprehensive and complementary set of plasma and neutral gas instruments, it has offered higher resolution data than ever before, with a dataset of over 6 years now. In this talk we will look at a some results about the plasma physical processes in and around the Martian ionosphere observed by the MAVEN satellite and discuss them in the context of Mars' atmospheric evolution, the effect of Mars' crustal magnetic fields, and what we can learn from it about other planets.

EP 3.4 Tue 12:00 EP-H1

Dynamo models reproducing the offset dipole of Mercury's magnetic field — •Patrick Kolhey[1], Daniel Heyner[1], Johannes Wicht[2], Thomas Gastine[3], and Ferdinand Plaschke[1] — [1]Institut für Geophysik und extraterrestrische Physik, Technische Universität Braunschweig, Braunschweig, Germany — [2]Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany — [3]Institut de Physique du Globe de Paris, Université de Paris, Paris, France

Since the discovery of Mercury's peculiar magnetic field it has raised questions about the dynamo process in its fluid core. The global magnetic field at the surface is rather weak compared to other planetary magnetic fields, strongly aligned to the planet's rotation axis and its magnetic equator is shifted towards north. Especially the latter characteristic is difficult to explain using common dynamo model setups. In this study we present new direct numerical simulations of the magnetohydrodynamical dynamo problem which include a stably stratified layer on top of the outer core, which can also reproduce the shift of the magnetic equator towards north. We revisit a model configuration for Mercury's dynamo action, which successfully reproduced the magnetic field features, in which core convection is driven by thermal buoyancy as well as compositional buoyancy (double-diffusive convection). While we find that this model configuration produces Mercury-like magnetic field only in a limited parameter range (Rayleigh and Ekman number), we show that also a simple codensity model is sufficient over a wide parameter range to produce Mercury-like magnetic fields.

EP 3.5 Tue 12:15 EP-H1

Revised Modular Model of Mercury's Magnetospheric Magnetic Field — •Kristin Pump, Daniel Heyner, and Ferdinand Plaschke — Institut für Geophysik und extraterrestrische Physik, TU Braunschweig

Mercury is the smallest an innermost planet of our solar system and has a dipole-dominated internal magnetic field that is relatively weak, very axisymmetric and significantly offset towards north. Through the interaction with the solar wind, this field leads to a magnetosphere. Compared to the magnetosphere of Earth, Mercury's magnetosphere is smaller and more dynamic. To understand the magnetospheric structures and processes we use in-situ MESSENGER data to develop a semi-empiric model, which can explain the observations and help to improve the mission planning for the BepiColombo mission en-route to Mercury.

We will present this semi-empiric KTH-model, a modular model to calculate the magnetic field inside the Hermean magnetosphere. Korth et al. (2015 and 2017) published a model, which is the basis for the KTH-Model. In this new version, the calculation of the magnetic field for the neutral current sheet is restructured based on observations rather than ad-hoc assumptions so that the description is more realistic. Furthermore, a new model is added to depict the partial ring current. An analysis of the residuals shows a better visibility of the field-aligned currents. In addition, this model offers the possibility to improve the main field determination.

EP 3.6 Tue 12:30 EP-H1

BepiColombo at Mercury: First close-in magnetic field measurements from the southern hemisphere — •Daniel Heyner — TU Braunschweig

The internal magnetic field of Mercury is best described by a northward offset dipole with almost zero obliquity. Its offset, weakness, axisymmetry and lack of secular variation still poses a challenge to dynamo theory. After NASA's Mariner 10 flybys in the 1970's and MESSENGER's orbital mission in 2011-2015, BepiColombo performed a flyby at Mercury in October 2021. For the first time, magnetic field measurements are obtained from the southern hemisphere close to the planet by the fluxgate magnetometer MPO-MAG. We will present an overview of the flyby data highlighting different plasma regions and compare the new in-situ data to magnetospheric models obtained from the previous missions to the innermost terrestrial planet. Does the flyby data reveal any secular variation? Has the dipole offset changed? These are some of the questions we will discuss with this unprecedented magnetometer data. We will close with a discussion on what is to be expected from the orbital phase of BepiColombo.

EP 3.7 Tue 12:45 EP-H1

Binary main-belt comet 288P — •Jessica Agarwal[1,2] and Yoonyoung Kim[1] — [1]Institut für Geophysik und Extraterrestrische Physik, TU Braunschweig — [2]Max-Planck-Institut für Sonnensystemforschung, Göttingen

Main-belt comets are asteroids that activate during subsequent perihelion passages, emitting dust like comets. The object 288P is currently the only known comet-like object that is also a gravitationally bound binary system. While binaries are common in the asteroid population, 288P is special even among these because of its combination of two similarly sized components and wide separation of about 100 times the object radius.

Possible formation scenarios include the likely involvement of rotational splitting, radiation-induced torques and outgassing-induced torques, but the detailed evolutionary history of the system remains to be understood. A key question in this context is whether one or both components are active.

We present data obtained with the Hubble Space Telescope in autumn 2021 that show the onset of activity in 288P as it approached perihelion.

EP 4: Planets and Small bodies

Time: Tuesday 14:00–15:35 Location: EP-H1

Invited Talk EP 4.1 Tue 14:00 EP-H1

Exploration of the Jupiter system with a small submillimetre wave telescope onboard the JUICE satellite — •Paul Hartogh — Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany

JUICE - JUpiter ICy moons Explorer it the first large class mission of ESA's Cosmic Vision 2015 - 2025 program. The JUICE satellite is planned to be launched in 2023 and will arrive in 2032. The primary mission in the Jupiter system will take about three years. The focus of the mission is Jupiter itself and the Galilean satellites, their internal oceans and potential habitability. Recent ground-based observations of Europa and Ganymede showed water vapor plumes, probably related to geysers on their surfaces. JUICE intends to identify the geysers, monitor their potential activity and molecular and isotopic composition in order to constrain satellite formation models and development processes (of chemical, physical and potentially biologic nature) in the interior of their oceans. Jupiter itself is seen as an archetype of a gas giant. A better understanding of its atmospheric processes will be a baseline for a better understanding of gas giants outside our solar system. JUICE will characterize the general circulation of Jupiter's atmosphere, its meteorology, chemistry and structure between the upper cloud deck and the ionosphere and magnetosphere. The Submillimetre Wave Instrument (SWI) is part of the JUICE science payload. SWI covers two spectral bands between 530 and 1275 GHz. The SWI functionalities and specifications as well as required technology developments during the last decades and how the unique capabilities of SWI will help to answer JUICE key science questions will be presented.

EP 4.2 Tue 14:30 EP-H1

A PE-based radio propagation simulation for glaciers and ice moons with depth-dependent permittivity profiles — •Gianluca Boccarella, Alex Kyriacou, and Pia Friend — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal

Enceladus Explorer (EnEx) is an initiative from the DLR to develop a melting probe that can reach a near surface water pocket on the ice moon Enceladus to search for microbial life. To find the water pocket a radar imaging system is needed, but the unknown permittivity of the surface ice will affect the accuracy of the measurements. We present an ice layering model of Enceladus including dielectric properties for the different types of ice layers, derived from Cassini data. We introduce a simulation which utilises Parabolic Equations (PE) to model radio propagation through inhomogeneous dielectric media such as ice environments on terrestrial glaciers or ice moons. Target objects embedded in the ice can be identified together with further reflections from the interface layers in the time-domain spectrum. By extracting the time of flight of respective reflected signals one can calculate the distance from the antennae to the target. Radar images, which would be obtained if a transmitter and receiver were placed on the melting probe moving vertically downwards through the ice, can be simulated and compared to each other for different permittivity profiles and targets. *This project is funded by the Enceladus Explorer Initiative of the DLR Space Administration

EP 4.3 Tue 14:45 EP-H1

On the Subsurface Exploration of Ocean Worlds in the Outer Solar System with the TRIPLE project — •Mia Giang Do[1], Jan Audehm[1], Dirk Heinen[1], Johanna Hermannsgabner[1], Sharif El Mentawi[1], Andreas Nöll[1], Shreyans Sakhare[1], Christopher Wiebusch[1], Yuting Ye[1], Simon Zierke[1], Clemens

Espe[2], Marco Feldmann[2], and Gero Francke[2] for the TRIPLE-nanoAUV-Collaboration — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]GSI - Gesellschaft für Systementwicklung und Instrumentierung mbH, Aachen, Germany

In search of extraterrestrial life, the icy moons in the solar system are prime targets as they are suspected to harbor a subsurface ocean of liquid water. Future space missions to explore these subsurface ocean worlds are of great interest. A mission scenario includes landing on the surface, penetrating through the massive ice shell with a probe, and diving into the ocean with an underwater vehicle that is collecting samples for identifying potential habitats. Within TRIPLE (Technologies for Rapid Ice Penetration and subglacial Lake Exploration), a system containing three components: a melting probe, a miniaturized autonomous underwater vehicle and an in-situ astrobiological laboratory, is in development. Aiming for a mission to Jupiter's moon Europa, the system will be tested in an analogue environment in Antarctica. The talk will give an overview of the TRIPLE project with a focus on the technological challenges of the melting probe and the latest status of the system. TRIPLE is a project line that has been initiated by the German Space Agency at DLR.

EP 4.4 Tue 15:00 EP-H1

TRIPLE-IceCraft - A Retrievable Melting Probe to Transport Scientific Payloads into Subglacial Lakes or Oceans — •Dirk Heinen[1], Simon Zierke[1], Jan Audehm[1], Mia Giang Do[1], Yuting Ye[1], Christopher Wiebusch[1], Marco Feldmann[2], Gero Francke[2], and Clemens Espe[2] — [1]RWTH Aachen University, III. Physikalisches Institut B, Otto-Blumenthal-Str., 52074 Aachen — [2]GSI - Gesellschaft für Systementwicklung und Instrumentierung mbH, Liebigstraße 26, 52070 Aachen

Within TRIPLE, initiated by the German Space Agency at DLR, Technologies for Rapid Ice Penetration and subglacial Lake Exploration are being researched. TRIPLE aims to explore the subglacial ocean of the Jovian moon Europa. Prior to this flight mission a technology demonstration is planned in Antarctica. For accessing the subglacial water reservoir, a drill or melting probe needs to penetrate the ice first.

The TRIPLE-IceCraft melting probe is currently in development. It is a modular bus system for transporting standardized payloads through ice. The design will be suitable for transporting a scientific payload through several hundred meters of ice, penetrating into a subglacial ocean or lake, and returning later to the surface. The TRIPLE-IceCraft will be demonstrated in an analog scenario at the Ekström Ice Shelf in Antarctica in 2023. In this talk we present the design and first results on subsystem tests of the TRIPLE-IceCraft.

EP 4.5 Tue 15:15 EP-H1

TRIPLE-IceCraft: A retrievable melting probe for transporting scientific payloads through glacial ice — •Simon Zierke[1], Dirk Heinen[1], Jan Audehm[1], Mia Giang Do[1], Yuting Ye[1], Christopher Wiebusch[1], Marco Feldmann[2], Gero Francke[2], and Clemens Espe[2] — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]GSI - Gesellschaft für Systementwicklung und Instrumentierung mbH, Aachen, Germany

The exploration of subglacial worlds is one of the greatest technological challenges for both space science and terrestrial glaciology. Within TRIPLE, initiated by the German Space Agency at DLR, technologies are being developed to address these challenges. One of the projects within TRIPLE is TRIPLE-IceCraft. Its goal is the development of an electrothermal drill as a terrestrial demonstrator for transporting payloads through an ice sheet of several hundred meters at a drilling velocity of several meters per hour. The same-named drill, TRIPLE-IceCraft, is a modular system including a cable which can be coiled and uncoiled into a dedicated compartment. The cable bears the weight of the drill and is used for communication and power. This allows the refreezing of the melt hole including the cable, so it can be operated even in cold glacial ice. The demonstration of the TRIPLE-IceCraft is planned close to the Antarctic research station Neumayer III located on the Ekström Ice Shelf in 2023. In this poster, we focus on the technical design of the TRIPLE-IceCraft.

EP 4.6 Tue 15:25 EP-H1

The In-Ice Sonar System for the TRIPLE Forefield Reconnaissance System — •Jan Audehm, Ben Burgmann, Mia Giang Do, Sharif El Mentawi, Dirk Heinen, Johanna Hermannsgabner, Andreas Nöll, Shreyans Sakhare, Christopher Wiebusch, Yuting Ye, and Simon Zierke — RWTH Aachen University - Physics Institute III B, Aachen, Germany

The icy moons Europa and Enceladus belong to the most interesting sites for the search of extra-terrestrial life in the solar system. It is assumed that in the oceans beneath their thick ice crusts preconditions for the emergence of life are fulfilled.

In the TRIPLE-project Technologies for Rapid Ice Penetration and subglacial Lake Exploration are developed to enable future exploration missions to the subsurface oceans of icy moons. These technologies will be demonstrated in a terrestrial analog scenario in Antarctica. Here, a melting probe will transport a small autonomous underwater vehicle (TRIPLE-nanoAUV) through the ice to an underlying water reservoir.

For this mission it is of great importance that the probe avoids obstacles on the path through the ice and can detect the transition between ice and water to anchor there. This task is addressed by TRIPLE-FRS being a Forefield Reconnaissance System using a hybrid system consisting of a radar, a sonar, and a permittivity sensor. Combining the complementary techniques assures a high performance of the FRS in ice as well as in water. This poster presents our concept for the sonar system and simulations of the acoustic transducer characteristics.

EP 5: Near Earth Space

Time: Tuesday 16:15–18:45 Location: EP-H1

Invited Talk EP 5.1 Tue 16:15 EP-H1

Investigating Earth's atmosphere and ionosphere from space: How GNSS radio occultation measurements contribute to monitor the atmosphere in a high spatial resolution — •Christina Arras[1], Ankur Kepkar[1,2], and Jens Wickert[1,2] — [1]German Research Centre for Geosciences GFZ, Potsdam, Germany — [2]Technische Universität Berlin, Germany

The GNSS radio occultation (RO) technique has been established successfully during the previous two decades. It evolved into a valuable observation tool for precise atmospheric and ionospheric vertical profiling. Radio occultation measurements provide globally distributed precise profiles of the refractivity of the Earth's atmosphere that can be converted into profiles of temperature, pressure, and water vapor in the lower neutral atmosphere and into electron density values in the ionosphere. Until today, there are about 14 million RO recordings available.

GNSS RO signals are very sensitive to vertical electron density gradients in the Earth's ionosphere. This becomes visible as strong fluctuations in, e.g., signal-to-noise ratio recordings, which allow detecting ionospheric disturbances like sporadic E layers in the lower ionospheric E region and equatorial plasma bubbles in the F-layer.

In this presentation, we will give an overview on RO data availability. We will review the data analysis to derive information on ionospheric disturbances in the E and F layer. Further, we discuss the sporadic E and plasma bubble formations that result from complex coupling processes in the thermosphere-ionosphere-magnetosphere system.

EP 5.2 Tue 16:45 EP-H1

Measurements of cosmic rays by a mini neutron monitor aboard the German research vessel Polarstern — •M. Zoska[1], S. Banjac[1], S. Burmeister[1], H. Giese[1], B. Heber[1], K. Herbst[1], L. Romaneesen[1], C. Schwerdt[2], D. Strauss[3], C. Wallmann[1], and M. Walter[1] — [1]Christian-Albrechts-Universität Kiel, Germany — [2]Deutsches Elektronen-Synchrotron Zeuthen, Germany — [3]North West University, Potchefstroom, South Africa

Galactic cosmic rays (GCRs) are a direct sample of material from far beyond the solar system. Measurements by various particle detectors have shown that the intensity varies on different timescales, caused by the Sun's activity. Many studies on GCR intensity decreases are based on the analysis of ground-based neutron monitors. Their measurements depend on the geomagnetic position, and the processes in the Earth's atmosphere. In order to get a better understanding of the geomagnetic filter over the solar cycle, the above groups agreed on a continous monitoring of the GCR flux as a function of latitude, by installing a portable device aboard the German research vessel Polarstern in 2012. The vessel is ideally suited for this research campaign because it covers extensive geomagnetic latitudes (i.e. goes from the Arctic to the Antarctic) at least once per year. Here we present themeasurements for different latitude surveys including the solar maximum in 2014 and solar minimum in 2019.

The Kiel team received funding from the European Union Horizon 2020 programme under grant agreement No 870405. We thank the crew of the Polarstern and the AWI for supporting our research campaign.

EP 5.3 Tue 17:00 EP-H1

Utilizing Cosmic Ray data as input for neutron-based soil moisture measurement — •Hanna Giese[1], Bernd Heber[1], Konstantin Herbst[1], and Martin Schrön[2] — [1]Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Kiel, Germany — [2]UFZ Helmholtz Center for Environmental Research, Leipzig, Germany

Neutrons on Earth interact with the soil and are substantially moderated by hydrogen atoms. Since the reflected neutron flux is a function of the soil water content, cosmic-ray neutron measurements above the ground can be used to estimate the average field soil moisture. Thus, if the local incoming neutron flux and the abundance of nearby hydrogen pools are known, the reflected neutron flux could be modeled and compared to observed detector count rates. However, the incoming neutrons are secondaries produced by interacting energetic Galactic Cosmic Rays (GCRs) in the atmosphere. The total neutron flux on the ground depends on the solar modulation-dependent GCR flux, the geomagnetic position, and the altitude within the atmosphere. So far, measurements of either the Jungfraujoch neutron monitor (NM) or a NM of similar cutoff rigidity have been used and altered to estimate the neutron flux at the position of each neutron detector. In this contribution we present a new method based on the Dorman function to directly compute the local neutron flux using remote neutron monitor data.

We received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 870405

EP 5.4 Tue 17:15 EP-H1

Empirical modelling of SSUSI-derived auroral ionization rates — •Stefan Bender[1,2], Patrick Espy[1,2], and Larry Paxton[3] — [1]Norwegian University of Science and Technology, Trondheim, Norway — [2]Birkeland Centre for Space Science, Bergen, Norway — [3]APL, Johns Hopkins University, Laurel, Maryland, USA

Solar, auroral, and radiation belt electrons enter the atmosphere at polar regions leading to ionization and affecting its chemistry. Climate models usually parametrize this ionization and the related changes in chemistry based on satellite particle measurements. Precise measurements of the particle and energy influx into the upper atmosphere are difficult because they vary substantially in location and time. Widely used particle data are derived from the POES and GOES satellite measurements which provide in-situ electron and proton spectra.

Here we use the electron energy and flux data products from the Special Sensor Ultraviolet Spectrographic Imager (SSUSI) instruments on board the Defense Meteorological Satellite Program (DMSP) satellites. The currently three operating satellites directly observe the auroral emissions in the UV from which electron energies and fluxes are inferred in the range from 2 keV to 20 keV. We use these observed electron energies and fluxes to calculate auroral ionization rates in the lower thermosphere (90–150 km). We present an empirical model of these ionization rates according to magnetic local time and geomagnetic latitude. The model is based on geomagnetic and solar flux indices and will be particularly targeted for use in climate models that include the upper atmosphere, such as WACCM-X or EDITh.

Invited Talk EP 5.5 Tue 17:30 EP-H1

Solar extreme events and their impact on the middle atmosphere — •Thomas Reddmann[1], Monali Borthakur[1], Miriam Sinnhuber[1], Ilya Usoskin[2], and Jan-Maik Wissing[3] — [1]Karlsruhe Institute of Technology, Germany — [2]University of Oulu, Finland — [3]University of Rostock, Germany

The Sun occasionally produces strong eruptions on its surface and in the corona. Within these strong eruptions, energetic particles are accelerated to high energies which hit the Earth within hours after the event. In addition, ejected plasma clouds can be accelerated towards the Earth causing severe geomagnetic disturbances which also cause particle precipitation. Here we study the impact of a one per millenium solar event on the atmosphere.

We use historical records and analyzed distributions of energy spectra to derive ionization rates for a combined extreme solar proton event and a geomagnetic storm which typically impact different parts of the atmosphere. The ionization rates for the extreme event are then used in simulations in the KASIMA and EMAC model which both include energetic particle induced chemistry. Their simplified production efficiency of NOx and HOx is compared to an ion chemistry model. We select specific dynamical situations for the event which represent a different vertical coupling in the atmosphere. Finally, we estimate the impact of the extreme event under those different dynamical situations on the chemical state in the atmosphere on the seasonal time scale in terms of ozone change and the global NOx budget together with the additional UV dose.

EP 5.6 Tue 18:00 EP-H1

Impact of chlorine ion chemistry on the ozone loss during very large solar proton events — •Monali Borthakur[1], Thomas Reddmann[1], Miriam Sinnhuber[1], Gabrielle Stiller[1], Thomas Von Clarmann[1], and Ilya Usoskin[2] — [1]Karlsruhe Institute of Technology, Karlsruhe, Germany — [2]University of Oulu, Oulu, Finland

Strong eruptions on the Sun can accelerate charged particles, mostly protons, to high energies, causing solar proton events (SPEs). Such energetic particles can precipitate upon the Earth's atmosphere, mostly in polar regions because of the geomagnetic shielding. SPE induced chlorine activation and its impact on stratospheric ozone in the polar northern atmosphere has been investigated using a 1D stacked-box model, of atmospheric ion and neutral composition, EXOTIC. Two SPEs were used as test fields: the Halloween SPE late October 2003 and an extreme event of 775 AD, which was derived from historical records of cosmogenic nuclides. We used observations of chlorine species and ozone from the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) on ENVISAT to evaluate model results for the Halloween event. Model experiments were carried out with full ion chemistry as well as with a common parameterisation scheme considering the formation of HOx and NOx. Additional ozone destruction due to the chlorine catalytic cycles was observed as well in the upper stratosphere and lower mesosphere. For the parameterised model runs, ozone depletion was observed to be the largest for full parameterisation.

EP 5.7 Tue 18:15 EP-H1

Ring current electron precipitation during storm events — •Alina Grishina[1,2], Yuri Shprits[1,2,3], Michael Wutzig[1], Hayley Allison[1], Nikita Aseev[1,2], Dedong Wang[1], and Matyas Szabo-Roberts[1,2] — [1]GFZ Potsdam, Potsdam, Germany — [2]University of Potsdam, Potsdam, Germany — [3]University of California, Los Angeles, Los Angeles, CA, USA

The particle flux in the near-Earth environment can increase by orders of magnitude during geomagnetically active periods. This leads to intensification of particle precipitation into Earth's atmosphere. The process potentially further affects atmospheric chemistry and temperature.

In this research, we concentrate on ring current electrons and investigate precipitation mechanisms on a short time scale using a numerical model based on the Fokker-Planck equation. We focus on understanding which kind of geomagnetic storm leads to stronger electron precipitation. For that, we considered two storms, corotating interaction region (CIR) and coronal mass ejection (CME) driven, and quantified impact on ring current. We validated results using observations made by POES satellite mission, low Earth orbiting meteorological satellites, and Van Allen Probes, and produced a dataset of precipitated fluxes that covers energy range from 1 keV to 1 MeV.

EP 5.8 Tue 18:30 EP-H1

Solar energetic particle event on 28 October 2021 as seen by the neutron monitor network — •Christian Steigies[1] and Rolf Bütikofer[2] — [1]Christian-Albrechts-Universität zu Kiel, Germany — [2]Universität Bern, Switzerland

The first solar energetic particle event during the current solar cycle 25 observed on ground, a so-called ground level enhancement (GLE), was detected on 28 October 2021 by a few neutron monitors of the worldwide network. At 16:09 UT the Athens GLE Alert system issued successfully an automatic alert. After the initial rapid increase in cosmic ray (CR) intensity, it slowly declined to background level within several hours. During times of raised CR intensities, the ionization rates in the atmosphere are increased and thereby radiation dose rates at aircraft altitudes may be enhanced depending on the location and the altitude. We present a first GLE analysis and assess the additional radiation doses that may be acquired on selected flight routes.

EP 6: Astrophysics

Time: Wednesday 11:00–13:15 Location: EP-H1

Invited Talk EP 6.1 Wed 11:00 EP-H1

Three-dimensional topology-driven magnetic reconnection — •Raquel Mäusle[1], Jean-Mathieu Teissier[1], and Wolf-Christian Müller[1,2] — [1]Technische Universität Berlin, Berlin, Germany — [2]Max-Planck/Princeton Center for Plasma Physics, Princeton, NJ, USA

Magnetic reconnection is a dissipative process, by which the magnetic field structure within a plasma is changed. It is important in many astrophysical systems, such as the Sun's corona, where it is believed to be of importance for the generation of solar flares.

We study a three-dimensional model of magnetic reconnection driven by magnetic field topology. Magnetic field lines in three-dimensional systems have the tendency to become highly entangled, making them exponentially sensitive to very small non-ideal effects. Therefore, entanglement could be the dominant mechanism for fast reconnection in low-resistivity plasmas, requiring far smaller current densities than otherwise needed. We investigate this model numerically using a fourth-order finite-volume scheme to solve the magnetohydrodynamic (MHD) equations. We start from a system with an initially constant magnetic field and line-tied boundaries, and drive it into a chaotic state in which reconnection is occuring. We study the dynamics of this system, the correlation between the field line entanglement and the occurrence of reconnection events, as well as the dependence of the reconnection rate on the resistivity.

In this talk I will introduce the model and numerical method employed and present our preliminary results.

EP 6.2 Wed 11:30 EP-H1

Very high-order subsonic magnetohydrodynamics solvers — •Jean-Mathieu Teissier[1] and Wolf-Christian Müller[1,2] — [1]Technische Universität Berlin, Berlin, Germany — [2]Max-Planck/Princeton Center for Plasma Physics, Princeton, NJ, USA

Magnetohydrodynamics (MHD) solvers are very important tools to analyze the large-scale, long time behaviour of astrophysical plasmas. Direct numerical simulations are however linked with high computational costs, so that a trade-off between accuracy of the results and the available resources has to be made. Higher-order solvers, i.e. solvers with a discretization order strictly higher than two, can typically achieve higher accuracy at a lower resolution than second-order ones, leading to an overall gain in performance. However, with increasing discretization order, solvers based on 3D-reconstructions may become prohibitively expensive. We present a finite-volume dimension-by-dimension method which allows to solve for the MHD equations at arbitrarily high discretization orders (we show results up to order ten), while maintaining affordable numerical costs for 3D problems. The magnetic field solenoidality is preserved up to machine precision with the constrained-transport approach. The study is limited to subsonic systems since shocks are not handled properly by higher-order methods. For a discretization order of six and above, the numerical dissipation is too low to prevent a pile-up of energy at small scales in turbulent systems, so that explicit diffusive terms need to be added. We present a formulation to do so, respecting the finite-volume and the constrained-transport frameworks.

EP 6.3 Wed 11:45 EP-H1

ComPol - A Compton polarimeter in a Nanosat — •Matthias Meier for the ComPol-Collaboration — Excellence Cluster ORIGINS, Garching, Germany — Technical University of Munich (TUM), Munich, Germany — Max-Planck Institute for Physics (MPP), Munich, Germany

The possibilities to investigate astrophysical compact objects are strongly limited. Due to the small size of these objects it is hardly possible to resolve their geometry. The CubeSat mission ComPol will investigate the black hole binary system Cygnus X-1. The goal is to improve its physical model by measuring the polarization of the hard X-ray spectrum. The information about the polarization can be extracted from the kinematics of the Compton scattering. A Silicon drift detector (SDD) is used as a scatterer. The SDD is stacked onto a CeBr3 calorimeter to be able to measure the full kinematics.

The talk will give an overview of the scientific motivation, the underlying physics and the detector setup.

This research was 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 6.4 Wed 12:00 EP-H1

A background study via simulations for the ComPol CubeSat experiment — •Cynthia Glas for the ComPol-Collaboration — Max-Planck-Institut für Physik, München, Deutschland — Technische Universität München, Deutschland

The objective of the CubeSat mission ComPol is to investigate the black hole binary Cygnus X-1 and to improve its physical model by measuring spectrum and polarization in the hard X-ray range. The information about the polarization can be extracted from the kinematics of Compton scattering.

To ensure a correct measurement, all physical processes occurring in the detectors, as well as common background sources need to be understood in advance. Therefore, the response of the setup to cosmic radiation in low earth orbit, as well as the south Atlantic anomaly is simulated with the Monte Carlo toolkit Geant4. Special focus was set on the cosmogenic activation of the CubeSat material. In order to determine which orbits are suitable for the ComPol mission, the activation of each material and the influence of radioactive decays originating from this activation on the individual detectors are studied in detail. To optimize the shielding strategy, simulations with different shielding configurations were performed. The talk will give an overview of the performed simulations, present the conclusions drawn from them, as well as discuss different shielding configurations.

This research was supported by the Excellence Cluster ORIGINS, which is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany*s Excellence Strategy.

EP 6.5 Wed 12:15 EP-H1

ComPol's way to space - preparing a CubeSat Compton Telescope for its in orbit verification (IOV) at the ISS — •Katrin Geigenberger for the ComPol-Collaboration — Max-Planck Institute for Physics (MPP), Munich, Germany — Technical University of Munich (TUM), Munich, Germany

ComPol will be a 3U-CubeSat with a Compton polarimeter consisting of a Silicon Drift Detector and a CeBr3 calorimeter. It will perform a long-term measurement of Cygnus X-1 in the hard X-ray range. The goal is to determine the polarization between 20 and 300 keV - a region where the polarization of Cygnus X-1 was hardly observed before. This talk is about the steps towards the first big milestone: a scaled-down version of ComPol's future instrumentation will be operated along with essential parts of the CubeSat bus on an external platform aboard the International Space Station (ISS). This IOV-mission will be a first real life demonstration of the detector system in space environment (background radiation, thermal loads and vacuum). The goal is to receive and process coincident signals from both detectors and to determine the influence of solar, x-ray, and cosmic radiation backgrounds. An overview of the current status of both mechanical and electrical hardware for the very first ComPol prototype will be given with focus on the space-mission specific challenges: e.g. shortage of room, protection of the sensitive detectors from solar radiation, constraints due to vacuum, and the investigation of the behavior at launch loads. This research was supported by the Excellence Cluster ORIGINS which is funded by the Deutsche Forschungsgemeinschaft (DFG).

EP 6.6 Wed 12:30 EP-H1

Stochastic Fluctuations of Cosmic Rays: From Voyager Data to Ionization Rate in Molecular Clouds — •Vo Hong Minh Phan[1], Florian Schulze[1], Philipp Mertsch[1], Sarah Recchia[2], and Stefano Gabici[3] — [1]Institute for Theoretical Particle Physics and Cosmology (TTK), RWTH Aachen University, Aachen, Germany — [2]Dipartimento di Fisica, Universitá di Torino, Torino, Italy — [3]University of Paris, CNRS, Astroparticule et Cosmologie, Paris, France

Data from the Voyager probes have provided us with the first measurement of cosmic ray intensities at MeV energies, an energy range that had previously not been explored. Simple extrapolations of models that fit data at GeV energies, e.g., from AMS-02, however, fail to reproduce the Voyager data in that the predicted intensities are too high. Oftentimes, this discrepancy is addressed by adding a break to the source spectrum or the diffusion coefficient in an ad hoc fashion, with a convincing physical explanation yet to be provided. In this talk, we will show that the discrete nature of cosmic-ray sources, which is usually ignored, is instead a more likely explanation. We model the distribution of intensities expected from a statistical model of discrete sources and show that its expectation value is not representative but has a spectral shape different from that for a typical configuration of sources. The Voyager proton and electron data are however compatible with the median of the intensity distribution. We will also discuss some preliminary results concerning the ionization rate induced by low-energy cosmic rays in molecular clouds.

EP 6.7 Wed 12:45 EP-H1

Efficient numerical simulations of dynamical cosmic-ray transport — •Stefan Kis[1], Pranab Deka[2], Ralf Kissmann[1], and Lukas Einkemmer[2] — [1]Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität Innsbruck, A-6020 Innsbruck, Austria — [2]Institut für Mathematik, Leopold-Franzens-Universität Innsbruck, A-6020 Innsbruck, Austria

Understanding the transport of charged particles in the Galaxy requires numerically solving a parabolic linear partial differential equation known as the cosmic-ray transport equation. Various codes aim at doing so, however most rely on a single approach in solving the time dependent problem and some do not provide substantial testing grounds for their solvers. We present a study case for various numerical time integrator schemes employed in solving the dynamical cosmic-ray transport equation. We asses the stability of the time integrator schemes and compare the numerical output against an analytical solution to determine their accuracy as well as judge their efficiency in the context of cosmic-ray transport.

EP 6.8 Wed 13:00 EP-H1

Relativistic regularized kappa distributions — •Linh Han Thanh — Ruhr-Universität Bochum

Within the framework of relativistic kinetic theory, a special relativistic generalization of isotropic kappa distributions is proposed, based on the requirement that in the non-relativistic limit the original distributions are recovered. By studying the moments, it is found that the relativistic description of the standard kappa distribution leads to an even greater restriction on allowed kappa values than in the non-relativistic case, whereas the relativistic regularized kappa distribution is able to remove all divergences.

EP 7: Astrophysics

Time: Wednesday 16:15–18:50 Location: EP-H1

EP 7.1 Wed 16:15 EP-H1

Comparison of HAWC's Eye data and Monte Carlo simulations — •Mark Meyers for the HAWC's Eye-Collaboration — Physics Institute III A, RWTH Aachen, Germany

HAWC's Eye is an array of Imaging Air-Cherenkov Telescopes which runs in coincidence with the High altitude water cherenkov observatory (HAWC), forming the first hybrid detector for cherenkov light, observing high energetic gamma rays and cosmic rays in the range of 100 GeV to 100 TeV. The goal is to enhance the performance, by improving the energy calibration and arrival direction reconstruction. In a Monte Carlo simulation, extensive air showers of protons and gammas are observed by an array of 55 telescopes. Properties of the produced detector images in the single telescopes are compared to those that have been produced in measurements, to verify the simulation. These measurements were obtained in stereo observations with two telescopes in three campaigns during the years 2019 and 2020. Potential ways to improve the simulation according to the obtained results will be investigated.

EP 7.2 Wed 16:30 EP-H1

Indication for a local source in the Northern Hemisphere from the joined energy spectrum and mass composition fit of the Pierre Auger Observatory and Telescope Array experiment — •Pavlo Plotko[1], Arjen van Vliet[1], Xavier Rodrigues[1], Domenik Ehlert[2], and Walter Winter[1] — [1]DESY, Platanenallee 6, 15738 Zeuthen, Germany — [2]Institutt for fysikk, NTNU, Trondheim, Norway

The Pierre Auger Observatory (PAO) and Telescope Array (TA) energy spectrum working groups report significant differences for the energy spectra above $10^{19.5}$ eV for the full fields of view of both experiments. In this work, we present a joined fit to the energy spectrum and mass composition measured by TA and PAO. Our fitting procedure includes the systematic uncertainty for both experiments. We carry out a detailed 3D model of UHECR sources that depends on the cosmological source evolution and a universal spectral power-law index and maximal rigidity. UHECR propagation is simulated within the "Propagation including Nuclear Cascade equations" (PriNCe) framework. Our fit results suggest that a local source in the Northern Hemisphere, that is only visible by the TA experiment, can reconcile PAO and TA measurements. For this proposed local source we discuss two possibilities: First, an object located at a few hundred Mpc with a heavy composition (corresponding to our best fit) and second a source at an even closer distance with a lighter composition (within the 1σ interval of our fit). Finally, we discuss possible source candidates taking into account the latest results of the TA hotspots.

EP 7.3 Wed 16:45 EP-H1

Measurement of the mass composition of ultra-high energy cosmic rays at the Pierre Auger Observatory using a novel model based on air-shower universality — Markus Roth, David Schmidt, •Maximilian Stadelmaier, and Darko Veberic — KIT, Karlsurhe, Germany

We present a model of extensive air showers that is based on the implications of air-shower universality. The model comprises the spatial and temporal densities of particles expected from extensive air-showers induced by cosmic rays. Therewith, the depth of the shower maximum and the relative muon content of an air shower can be reconstructed solely from data collected by the surface detector of the Pierre Auger Observatory and the upgraded AugerPrime. Using these two observables, the logarithmic atomic mass of cosmic rays can be reconstructed on an event-by-event basis with sufficient accuracy to discriminate light from heavy primary particles. The method is calibrated using hybrid measurements from the surface detector and the fluorescence telescopes of Auger. Furthermore, we present results on the mass composition of ultra high-energy cosmic rays as estimated using the universality-based reconstruction.

EP 7.4 Wed 17:00 EP-H1

Analytic examination of AGN variability in a two-zone model — •Vito Aberham and Felix Spanier — Institut für Theoretische Astrophysik, Albert-Ueberle-Straße 2, 69120 Heidelberg

The variability of active galactic nuclei is examined analytically using a two-zone model that injects particles in a monoenergetic fashion. The elemental PDEs of both zones are solved neglecting terms behaving as second-order Fermi acceleration. The time-dependent behavior of the obtained particle distributions is inspected by employing a variable source function. As time approaches infinity the steady state distribution functions are recovered displaying the expected spectral indices. Being typical for BL Lac objects parameter estimates from a model fitting the SED of the blazar TXS 0506+056 are incorporated. Corresponding photon and neutrino fluxes in both local jet and earth frame are determined and compared to observations. The general time-dependence of photon light curves in various bands and the neutrino flux is evaluated by implementing a time-dependent initial source function. The variability timescales of relevant quantities are ultimately inferred also considering the effect of different particle species. It is demonstrated how the analytical results can be utilized to cross-check results from numerical simulation as well as to interpret observational data collected at different times.

EP 7.5 Wed 17:15 EP-H1

ExHaLe-jet: An extended hadro-leptonic jet model for blazars — •Michael Zacharias[1,2], Anita Reimer[3], Catherine Boisson[1], and Andreas Zech[1] — [1]LUTH, Observatoire de Paris, Meudon, France — [2]Centre for Space Research, North-West University, Potchefstroom, South Africa — [3]Institut für Astro- und Teilchenphysik, Universität Innsbruck, Austria

Blazars – active galaxies with the jet pointing at Earth – emit across all electromagnetic wavelengths. The so-called tne-zone model has described well both quiescent and flaring states, however it cannot explain the radio emission. In order to self-consistently describe the entire electromagnetic spectrum, extended jet models are necessary. Notably, kinetic descriptions of extended jets can provide the temporal and spatial evolution of the particle species and the full electromagnetic output. Here, we present the initial results of a recently developed lepto-hadronic, extended-jet code. As protons take much longer than electrons to lose their energy, they can transport energy over much larger distances than electrons and are therefore essential for the energy transport in the jet. Furthermore, protons can inject additional leptons through pion production and decay, as well as Bethe-Heitler pair production, which can explain a dominant leptonic radiation signal while still producing neutrinos. We will present a detailed parameter study and provide insights into the different blazar sub-classes.

EP 7.6 Wed 17:30 EP-H1

Modeling the leptonic origin of the low-frequency emission from blazar PKS 1502+106 — •Frederike Apel — Ruhr-Universität Bochum

In this work, we model the multi-wavelength emission from the blazar PKS 1502+106. This object is a candidate source of a high-energy neutrino observed by the IceCube experiment in 2019. We show that the emission from the source in the range from radio to infrared can be well explained by radiative (synchrotron) cooling of electrons accelerated in the relativistic jet. First, we show how simple analytical considerations can be used to obtain a rough estimate of the physical parameters of the source. Then, using time-dependent numerical simulations, we obtain a more accurate result that reproduces the observed spectral energy distribution. This result sheds light on the physical properties of the source, and can be used in the future to better constrain its nature as a hadronic accelerator.

EP 7.7 Wed 17:45 EP-H1

Time-dependent simulations of a Blazar-Flare — •Maximilian Albrecht and Felix Spanier — Universität Heidelberg - ITA

Active galactic nucleis have been discussed as possible accelerators of high-energy cosmic rays for quite some time. When the Blazar TXS 0506+056 was identified as the source of the high-energy Muon neutrino (IceCube-170922A) detected by the IceCube telescope in 2017 as a result of a large-scale multimessenger campaign, it was a first indication of possible correlations of the increased spectral activity of such sources and their neutrino production. Studies of this correlation by simulating the acceleration processes taking place in the jet and their photon and neutrino emission therefore allow conclusions to be drawn about the composition of the jet plasma by comparing them with the observed fluxes. In this talk, the two-zone model UNICORN-0d is used to perform a self-consistent modeling of the eruption of TXS 0506+056 in 2017 based on the existing multimessenger data. A special focus will be put upon the data in the very high energy regime. The importance of these data being taken simultaneously is discussed by using time-resolved simulations of an emission flare. In contrast to previous models this approach addresses the possibility that the data from 2017 might represent different emission-states of the Blazar.

EP 7.8 Wed 18:00 EP-H1

The candidate tidal disruption event AT2019fdr coincident with a high-energy neutrino — •Simeon Reusch — Deutsches Elektronen Synchrotron DESY, Platanenallee 6, D-15738 Zeuthen, Germany — Institut für Physik, Humboldt-Universität zu Berlin, D-12489 Berlin, Germany

The origins of the high-energy cosmic neutrino flux remain largely unknown. Last year, a high-energy neutrino was associated with the tidal disruption event (TDE) AT2019dsg.

In this talk we present AT2019fdr, an exceptionally luminous TDE candidate, coincident with another high-energy neutrino detected by IceCube. We will present observations that further support a TDE origin of this flare. These include a bright dust echo and soft late-time X-ray emission. The probability of finding two such bright events in neutrino follow-up by chance is just 0.034%.

Furthermore, we have evaluated several models for neutrino production and show that AT2019fdr is capable of producing the observed high-energy neutrino. This reinforces the case for TDEs as neutrino sources.

EP 7.9 Wed 18:15 EP-H1

Search for short time-scale transients from the Sculptor galaxy — •Annanay Jaitly — Humboldt-Universität zu Berlin, Berlin, Germany

Astrophysical sources show variability in their emissions over a range of time-scales. For short time-scale transients like fast radio bursts, no very-high-energy gamma-ray counterparts have been detected so far and there is a general lack of tools suited to search for such phenomena. We developed and tested a plugin for the gammapy python package. It is is a tool capable of searching gamma-ray telescope data for transient phenomenon over arbitrary timescales. It scans the given field of view for clusters of events within user-defined time and angular separation intervals. To test the performance of said tool, we studied the Sculptor galaxy (NGC 253); it was chosen because Fermi-LAT previously reported a magnetar giant flare near this source. In this contribution we present the main features of the developed software, and our results from searching the Sculptor galaxy for short-timescale candidates using it.

EP 7.10 Wed 18:30 EP-H1

Understanding the multi-wavelength variabilty of TeV blazar VER J0521+211 with high-energy particle interactions — •Anastasiia Omeliukh — Ruhr University Bochum, Faculty of Physics and Astronomy, Astronomical Institute, Universitätsstr. 150, 44801 Bochum, Germany

In spring 2020, the MAGIC collaboration detected photons with energies above 200 GeV from the source VER J0521+211 which provides evidence of efficient particle acceleration in a relativistic jet. The monitoring of the source's short-term variability in very-high-energy gamma rays is complemented by simultaneous data from other observatories in radio, optical, X-ray, and GeV gamma rays. We perform multi-wavelength modeling of this source with a fully self-consistent one-zone leptohadronic model to explain four different multi-wavelength data sets. While the radio and optical fluxes seem to originate from electron synchrotron emission, in this model the gamma-ray fluxes are well explained by electromagnetic cascades induced by proton interactions.

EP 7.11 Wed 18:40 EP-H1

Gravitation explained as a physical interaction instead of a geometric space-time model. — •Osvaldo Domann — Stephanstr. 42, 85077 Manching

GR is the theory of gravitation of the SM. It is a mathematical approach from 1915 based on geometric reflections, arriving to the wondrous concept of space-time curvature. GR resists all intents of integration into a unified field theory and is not compatible with quantum mechanics. An approach is presented for a gravitation theory that is based on the representation of a subatomic particle (SP) as a focal point of rays of Fundamental Particles (FPs) that move from infinite to infinite. The energy of a subatomic particle is stored at its FPs as rotation defining angular momenta. With this representation all SPs interact permanently through the angular momenta of their FPs. The approach explains gravitation as the result of the reintegration of migrated electrons and positrons to their nuclei. Gravitation is composed of a Newton and an Ampere component, with the Newton component dominant at sub galactic distances and the Ampere component at galactic distances. A positive Ampere component explains the speed flattening of galaxies and a negative Ampere component the expansion. Neither dark matter nor dark energy is required and the model is compatible with quantum mechanics. More at: www.odomann.com

EP 8: Astroparticles: Invited talks (joint session T/EP)

Time: Thursday 11:00–12:30 Location: T-H15

Invited Talk EP 8.1 Thu 11:00 T-H15
Borexino looks in the direction of solar neutrinos — •Livia Ludhova for the Borexino-Collaboration — Forschungszentrum Jülich, Jülich, Germany — RWTH Aachen University, Aachen, Germany

Borexino is a 280-ton liquid scintillator detector located at the LNGS in Italy. Characterized by an unprecedented radio-purity, it has succeeded in providing several milestone measurements of MeV-scale neutrinos, with the main focus on solar neutrinos. The latter are the only direct probe of the Hydrogen-to-Helium fusion powering our Sun. The European Physical Society awarded the 2021 Giuseppe and Vanna Cocconi Prize to the Borexino Collaboration for the ground-breaking observation of solar neutrinos from the pp chain and CNO cycle that provided unique and comprehensive tests of the Sun as a nuclear fusion engine. Borexino has developed a new method, Correlated and Integrated Directionality (CID), to exploit the sub-dominant directional Cherenkov light in a liquid scintillator detector. This technique can disentangle the solar neutrino signal, correlated with the known position of the Sun, from the isotropic background. In the region of interest dominated by the signal from 0.862 MeV Be-7 solar neutrinos, the no-solar neutrino hypothesis has been excluded with $>5\sigma$ C.L. This novel method is readily applicable to next generation experiments. The talk will focus on the recent Borexino solar neutrino results, including the motivation, analysis details, as well as their interpretation.

Invited Talk EP 8.2 Thu 11:30 T-H15
Gravitational waves - a new probe of the early Universe — •Valerie Domcke — CERN, Geneva, Switzerland

Due to their extremely weak interactions with the matter content of the Universe, gravitational waves generated right after the Big Bang can traverse the Universe basically unperturbed, carrying information about their production processes and the expansion history of our Universe. This makes them a unique probe of BSM physcis at very high energies. I will talk about possible next steps in this field, including the search for the stochastic gravitational wave background and new ideas for searching for gravitational waves at ultra-high frequencies.

Invited Talk EP 8.3 Thu 12:00 T-H15
Gravitational wave detectors - current and future challenges — •Michèle Heurs — Leibniz Universität Hannover

Since the first direct detection in 2015, gravitational wave signals have been enriching the field of multi-messenger astronomy with insights into formerly "invisible" regimes of the universe. Despite their mind-boggling sensitivities, the current (second) generation of ground-based gravitational wave detectors are limited by various noise sources in their detection band, in particular quantum noise, thermal noise, and seismic noise. Next-generation detectors (e.g. Einstein Telescope, Cosmic Explorer) aim for sensitivities one or two orders of magnitude better even, making innovative techniques for noise reduction or mitigation a requirement. This talk will present challenges and technical developments on the road to ever-higher gravitational wave event detection rates.

EP 9: Mitgliederversammlung Extraterrestrische Physik

Time: Thursday 12:45–13:45 Location: EP-MV

Mitgliederversammlung EP / General assembly EP

EP 10: Astroparticles: Invited topical talks (joint session T/EP)

Time: Thursday 14:00–15:40 Location: T-H15

Invited Topical Talk EP 10.1 Thu 14:00 T-H15
LND - A ("Made in Germany") Radiation Monitor Operating at the far Side of the Moon — •Sönke Burmeister[1], Shenyi Zhang[2], Jia Yu[1], Zigong Xu[1], Stephan Böttcher[1], and Robert Wimmer-Schweingruber[1] — [1]Institut für Experimentelle und Angewandte Physik, Uni Kiel — [2]NSSC, Chinese Academy of Science

Space Radiation is one of the major concerns in human space flight. Of course, this also applies to human exploration of the Moon. On the lunar surface, this consists of chronic exposure to galactic cosmic rays and sporadic solar particle events. The interaction of this radiation field with the lunar soil leads to a third component that consists of neutral particles, i.e., neutrons and gamma radiation. Chang'E 4 is the Chinese mission that landed on the far side of the Moon on January 3rd, 2019. It consists of a lander, a rover, and a relay spacecraft. The LND (Lunar Lander Neutrons and Dosimetry) instrument that was built by CAU is located inside the lander under an opening lid. It consists of a stack of ten segmented Si solid-state detectors (SSDs), which form a particle telescope to measure charged particles (electrons from 0.5 MeV to several MeV, protons 8-35 MeV, and heavier nuclei 17-75 MeV/nuc). A special geometrical arrangement allows observations of fast neutrons (and gamma-rays) that are also important for dosimetry purposes. Thermal neutrons are measured by using a very thin Gd conversion foil sandwiched between two SSDs. The Lunar Lander Neutrons and Dosimetry experiment aboard China's Chang'E 4 lander has made the first ever measurements of the radiation exposure to both charged and neutral particles on the lunar surface.

Invited Topical Talk EP 10.2 Thu 14:25 T-H15
Energetic Pulsar Environments and the Origins of Galactic Cosmic Rays — •Alison Mitchell — Erlangen Centre for Astroparticle Physics, FAU, Erlangen, Germany

Cosmic Rays - and their origins - have fascinated Physicists for over a hundred years. Within our Milky Way Galaxy, particles are known to reach energies beyond the so-called Cosmic Ray *knee*, a spectral break at ~3 PeV in the all particle cosmic ray spectrum. However, evidence for the particle accelerators reach PeV energies - PeVatrons - has proven elusive. Only within the last five years have astrophysical sources of gamma-rays above 100 TeV been identified; gamma-rays produced through interactions of particles with PeV energies. Many of these sources are associated with known energetic pulsars.

In this talk, I will review the current census of PeVatrons and discuss implications for our understanding of pulsar environments. There are several open questions to grapple with: Which particle species are being accelerated - leptonic or hadronic? How are the particles transported through the surrounding medium? What is the maximum energy limit for particle acceleration in pulsar environments? In the near future, data from current and forthcoming facilities will help us to address these questions.

Invited Topical Talk EP 10.3 Thu 14:50 T-H15
Looking forward to exciting physics with FASER — •Felix Kling — DESY

Physics searches and measurements at high-energy collider experiments traditionally focus on the high-pT region. However, if particles are light and weakly-coupled, this focus may be completely misguided: light particles are typically highly collimated around the beam line, allowing sensitive searches with small detectors, and even extremely weakly-coupled particles may be produced in large numbers there. The FASER experiment will use the opportunity and extend the LHC's physic potential by searching for long-lived particles and studying neutrino interactions at TeV energies. In this talk, I will present the physics potential of FASER for new physics searches, neutrino physics and QCD and astro-particle physics.

Invited Topical Talk EP 10.4 Thu 15:15 T-H15

Astroparticle physics at the LHC: Exploring the forward region with cross-section measurements — •Hans Dembinski — Fakultät Physik, Technische Universität Dortmund, Dortmund, Germany

Astroparticle physics is the study of the non-thermal universe with gamma rays, neutrinos, and cosmic rays. Cosmic rays are abundantly produced in cosmic accelerators, like supernova remnants. Some gamma rays and neutrinos are produced indirectly in interactions of cosmic rays with matter in the source, and cosmic rays interact with Earth's atmosphere to produce air showers, which are observed by ground-based cosmic ray observatories and contribute the main background to gamma ray and neutrino observatories. QCD cross-sections for the forward production of hadrons with light and heavy flavor are therefore needed to interpret astroparticle measurements. The experiments at the Large Hadron Collider (LHC) have powerful instruments to measure forward production, but data are more sparse compared to central production. I will summarize the state-of-the-art of forward cross-section measurements at the LHC from the point of view of astroparticle physics and give an outlook into the opportunities in near future with the upcoming run of the LHC and the planned pilot run with oxygen beams.

EP 11: Astroparticles: From the source to the detector (joint session EP/T)

Time: Thursday 16:15–18:30 Location: EP-H1

EP 11.1 Thu 16:15 EP-H1

Multi-messenger studies with gravitational waves and neutrinos — •Tista Mukherjee for the IceCube-Collaboration — Institute for Astroparticle Physics (IAP), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

IceCube is a neutrino observatory located in Antarctica. Since its discovery of a high-energy neutrino (IC170922A) from the blazar TXS0506+056 in 2017, neutrino astronomy has been established as a viable option to probe the high-energy Universe. Neutrinos can carry undistorted information about their respective astrophysical sources, thus can serve as a cosmic 'messenger' to us. There are other potential messengers as well, e.g. gravitational waves (GW) and cosmic rays other than the traditional photons of various wavelengths. Combining interesting signals of such messengers available from different observatories leads us towards multi-messenger searches, allowing us to address many of the so far unanswered questions about the fundamentals of this Universe, such as the origin of ultra-high-energy cosmic ray sources. So far, we have the knowledge of detecting electromagnetic signal in multiple wavelengths, spatially and temporally correlated with GW and high-energy neutrinos, as two separate events. However, there is still a missing link as we have not been able to correlate GW with neutrino signals. The aim of my work is to contribute in this aspect, searching for Virgo detected GW counterparts of neutrino events detected by IceCube, including low-energy neutrinos as well as sub-threshold GW events in our analysis. The work plan and initial results will be discussed in this talk.

EP 11.2 Thu 16:30 EP-H1

Multi-messenger characterization of Mrk501 during historically low X-ray and gamma-ray activity — •Lea Heckmann[1], David Paneque[1], Sargis Gasparyan[2], Matteo Cerruti[3], Narek Sahakyan[2], and Axel Arbet-Engels[1] for the Multi-wavelength collaborators and the MAGIC and Fermi-LAT-Collaboration — [1]Max-Planck-Institut für Physik, D-80805 München, Germany — [2]ICRANet-Armenia, Marshall Baghramian Avenue 24a, Yerevan 0019, Armenia — [3]Institut de Ciències del Cosmos (ICCUB), Universitat de Barcelona (IEEC-UB), Martí i Franquès 1, 8 E08028 Barcelona, Spain

Blazars are the most numerous very-high-energy (>0.2 TeV, VHE) gamma-ray emitters, due to their continuous and very luminous emission; but they are far from being understood.

In this contribution we describe the multi-wavelength behavior of Mrk501, one of our closest and therefore brightest blazars, from 2017 to 2020. Alongside the dense monitoring campaign over this four years, three long observations with NuSTAR were conducted displaying various low-activity flux levels for the hard X-ray emission. This very comprehensive data set reveals a historically low X-ray and VHE gamma-ray emission period lasting two years. Using the low-activity broadband spectral energy distribution (SED) and data published by IceCube, we investigate the nature of the low state. Additionally, we try to explain the evolution of the broadband SED data during the low state to evaluate its potential of being the baseline emission of Mrk501 that is usually outshone by more dominant and variable components.

EP 11.3 Thu 16:45 EP-H1

Hadronic models of active galaxies to constrain cosmic-ray acceleration — •Xavier Rodrigues — DESY Zeuthen

In a new era of multi-messenger observatories, numerical models can help shed light on what are the sources of the astrophysical neutrinos and the ultra-high-energy cosmic rays. In this talk I discuss recent results on active galactic nuclei (AGN) as multi-messenger sources, based on numerical simulations of photonuclear cosmic-ray interactions. Assuming AGN jets can reaccelerate cosmic rays up to the EeV regime, I will show that an AGN population may in fact dominate the observed flux and chemical composition of ultra-high-energy cosmic rays. Under certain conditions, the accompanying neutrino flux may be observable by future EeV neutrino telescopes, while respecting the current IceCube limits at PeV energies.

EP 11.4 Thu 17:00 EP-H1

Neutrino Emission during Supermassive and stellar mass Binary Black Hole Mergers — •Ilja Jaroschewski[1], Julia Becker Tjus[1], and Peter L. Biermann[2,3] — [1]Theoretische Physik IV, Ruhr-Universität Bochum — [2]MPI for Radioastr., Bonn — [3]Dept. of Phys. & Astron., Univ. Alabama, Tuscaloosa, AL, USA

Ever since the discovery of a diffuse astrophysical neutrino flux by IceCube, the question arose which sources contribute most. With several neutrino-blazar associations since the first high-probability association of such a neutrino to the blazar TXS 0506+056 in 2017, there is an indication that at least a non-negligible part of this diffuse neutrino flux emerges from blazars.

As over ninety stellar mass binary black hole mergers were already detected via gravitational waves (GWs), with more to come, there are strong indications that supermassive black holes (SMBHs) in galaxy centers, and thus blazars, also merge and have had at least one merger in their lifetime. Such a merger is almost always accompanied by a change of observable jet direction, leading to interactions of a preceding jet with surrounding molecular clouds and neutrino productions.

By creating a connection between neutrinos and GWs, we set limits on how much energy can be emitted in form of neutrinos in each merger of binary SMBHs and stellar mass black holes and estimate their contributions to the diffuse neutrino flux that is measured by IceCube. As neutrino production is directly connected to high energy cosmic ray interactions, the contribution of these sources to the cosmic ray injection rate is established.

EP 11.5 Thu 17:15 EP-H1

Search for high-energy neutrinos from blazars with IceCube — •Cristina Lagunas Gualda for the IceCube-Collaboration — DESY Zeuthen

The IceCube Neutrino Observatory is the world's largest neutrino telescope, instrumenting one cubic kilometre of Antarctic ice. IceCube started its operation with full configuration in 2011 and a diffuse flux of neutrinos was discovered in 2013. To this day the sources of those neutrinos are still largely unknown. One of the most promising neutrino source candidates is blazars, Active Galactic Nuclei with jets aligned towards Earth.

In 2018 IceCube reported the first clearly identified observation of an astrophysical high-energy neutrino, IC170922A, in spatial and temporal coincidence with blazar TXS 0506+056. Other examples of coincidences that have been observed with lower significance are, but not limited to, IC190730A with blazar PKS 1506+012 and IC141209A with blazar GB6 J1040+0617. What these have in common is that they involve a blazar and a high-energy neutrino with a high probability of being astrophysical in origin (neutrino alert). These coincidences can be combined to calculate a global p-value by performing a stacking analysis. Here we present the results obtained with the Fourth Catalog of Active Galactic Nuclei detected by Fermi-LAT (4LAC-DR2, for Data Release 2) and neutrinos detected by IceCube between 2011 and 2020 that would have passed the neutrino alert criteria.

EP 11.6 Thu 17:30 EP-H1

Comparison of Models for Predicting Periodic Gamma-Ray & Neutrino Emissions From Blazars — •Armin Ghorbanietemad, Ilja Jaroschewski, and Julia Becker Tjus — Theoretische Physik IV, Ruhr-Unviersität Bochum

There are several indications that electromagnetic emissions from blazars have quasi-periodic variability, ranging from minutes to years. The long-term periodicity in the span of years is particularly evident in gamma-ray observations with the Fermi LAT instrument. Two separate high probability associations of neutrinos, detected by IceCube in 2014/15 and 2017, to the blazar TXS0506+056 further indicate that blazars are neutrino emitters. These two flares can be interpreted as a possible periodicity. It is the aim of this work to develop a general set of models that can explain the periodic gamma-ray and neutrino emissions from blazars.

In this talk, we present models with single supermassive black holes as well as supermassive binary black hole mergers at the centers of blazers. Our focus lies on supermassive binary black hole mergers, due to them radiating gravitational waves which could be detectable by the Laser-interferometer Space Antenna (LISA). The binary systems are characterized by the change of jet direction accompanied by jet precession close to an imminent merger. This allows predictions of possible neutrino and gravitational wave emissions from blazars with quasi-periodic behavior.

EP 11.7 Thu 17:45 EP-H1

First science results from the X-ray telescope STIX on Solar Orbiter — •Alexander Warmuth, Frederic Schuller, and Gottfried Mann — Leibniz -Institut für Astrophysik Potsdam (AIP)

The ESA mission Solar Orbiter was successfully launched in 2020, with the main goal of improving our understanding of how the Sun creates and controls the heliosphere. The Spectrometer/Telescope for Imaging X-rays (STIX) is one of six remote-sensing instruments on board and provides imaging spectroscopy of solar flares in the energy range of 4 to 150 keV. Thus, STIX is able to measure quantitatively both the parameters of the hot flare plasma and the characteristics of the accelerated electrons. Together with the other instruments on Solar Orbiter as well as with other space-borne and ground based observational assets, STIX studies energy release and particle acceleration in solar flares. This talk will be focused on the first science results obtained during the cruise phase of Solar Orbiter (2020 and 2021). This includes observations of microflares, constraints on flare energetics, collaborative studies of gamma-ray flares together with Fermi, and the investigation of flare-associated solar energetic particle events.

EP 11.8 Thu 18:00 EP-H1

Unfolding the muon neutrino energy spectrum from 10 years of IceCube data with DSEA+ — •Leonora Kardum, Karolin Hymon, Johannes Werthebach, Pascal Gutjahr, Tim Ruhe, and Jean-Marco Alameddine for the IceCube-Collaboration — Astroparticle Physics WG Rhode, TU Dortmund University, Germany

Neutrinos, the most elusive particles in the Standard Model, can travel tremendous distances unaffected by magnetic fields or encountered particles from distant sources in the Universe. As this makes them perfect information carriers, many attempts at uncovering their properties are made. The IceCube Neutrino Observatory, a cubic kilometer detector embedded in the South Pole ice, is capable of detecting neutrinos from several GeV up to PeV energies enabling precise reconstruction of the neutrino spectrum. Determining the accurate spectrum is of great importance to neutrino physics, especially in differentiating the three predicted components - prompt, conventional, and astrophysical, of which only the latter two have been detected so far. The Dortmund Spectrum Estimation Algorithm (DSEA+) is a novel approach to unfolding the energy spectrum from measured experimental quantities that effectively translates ill-posed problems to multinomial classification solvable using readily available machine learning tools. The current status of applying DSEA+ on 10 years of IceCube data will be presented.

EP 11.9 Thu 18:15 EP-H1

Recent solar and geoneutrino results from Borexino — •Sindhujha Kumaran for the Borexino-Collaboration — Forschungszentrum Jülich - Institute for Nuclear Physics, IKP-2, Jülich, Germany — III. Physikalisches Institut B, RWTH Aachen University, Aachen, Germany

Borexino is a 280-ton liquid scintillator experiment which ran from May 2007 until October 2021 at the Laboratori Nazionali del Gran Sasso (LNGS), Italy. The main goals of Borexino include the measurement of solar neutrinos and geoneutrinos. The extreme radiopurity and thermal stability of the detector have proven to be valuable assets in achieving these goals. Borexino has not only performed a complete spectroscopy of the dominant pp-chain solar neutrinos but has also provided the first direct experimental evidence of the rare CNO-cycle neutrinos. These measurements have several implications for solar and stellar Physics and further improvements are envisioned using the full dataset. In addition, it has recently presented the first directional measurement of sub-MeV solar neutrinos using the subdominant Cherenkov light, through a novel technique called Correlated and Integrated Directionality (CID). This method can be further combined with a typical spectral fit and can also prove valuable for next-generation liquid scintillator detectors. The latest geoneutrino measurement from Borexino included a substantial improvement in the precision as well as the rejection of the no-mantle signal with a high significance. This group report will summarize all these recent solar and geoneutrino results of Borexino.

EP 12: Sun and Heliosphere

Time: Friday 11:00–14:00 Location: EP-H1

Invited Talk EP 12.1 Fri 11:00 EP-H1

Linking Solar Eruptions and Energetic Particles through Observations and Modeling — •Frederic Effenberger — Ruhr-Universität Bochum, Bochum, Germany

Cosmic rays and energetic particles constitute one of the fundamental components of space plasmas and our Heliospheric environment. However, the relation between different energetic particle populations accelerated in the solar atmosphere and detected in interplanetary space is not well established. Observational studies during the last years demonstrated the still poorly understood existence of a connection between solar flare signatures of accelerated particles at the Sun and the corresponding solar energetic particles (SEPs) detected at 1 AU. It is thus important to make progress towards answering the question: Under which circumstances do these two observations point to the same population of accelerated particles? Here, we will discuss recent progress concerned with this issue. We illustrate the potential for observations and simultaneous modeling of the escaping and precipitating electron populations to constrain the plasma properties of the flaring region and interplanetary medium. In particular, with the recently launched Parker Solar Probe and Solar Orbiter missions, which explore the Sun from a close distance and with unprecedented detail, new insights into these questions can be expected. We emphasize the importance of such studies for the fundamental understanding of physical processes in space plasmas and for our space weather forecasting capabilities.

EP 12.2 Fri 11:30 EP-H1

Determining Pitch-Angle Diffusion Coefficients for Electrons in Whistler Turbulence — •Felix Spanier[1], Cedric Schreiner[2,3], and Reinhard Schlickeiser[4,5] — [1]Institut für Theoretische Astrophysik, Universität Heidelberg, Albert-Ueberle-Strasse 2, 69120 Heidelberg — [2]Centre for Space Research, Northwest-University, Potchefstroom 2520, South Africa — [3]Max-Planck-Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077 Göttingen, — [4]Institut für Theoretische Physik IV, Ruhr-Universität Bochum, Universitätsstrasse 150, 44801 Bochum, Germany — [5]Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität zu Kiel, Leibnizstr. 15, 24118 Kiel

Transport of energetic electrons in the heliosphere is governed by resonant interaction with plasma waves, for electrons with sub-GeV kinetic energies specifically with dispersive modes in the whistler regime.

We have performed Particle-in-Cell simulations of kinetic turbulence using parameters similar to those found in the heliosphere. Test-particle electrons are injected into the simulation. The pitch-angle diffusion coefficients of these test particles were analyzed using a novel method.

An analytical model for electron transport in left- and right-handed is derived and the numerical results are compared to this model.

EP 12.3 Fri 11:45 EP-H1

On Compressible Turbulence in the Inner Heliosheath — •Horst Fichtner[1], Jens Kleimann[1], Peter Yoon[2], Klaus Scherer[1], Sean Oughton[3], and Eugene Engelbrecht[4] — [1]Institut für Theoretische Physik IV, Ruhr-Universität Bochum, 44780 Bochum, Germany — [2]Institute for Physical Science and Technology, University of Maryland, College Park, USA — [3]Department of Mathematics and Statistics, University of Waikato, Hamilton 3240, New Zealand — [4]Centre for Space Research, North-West University, Potchefstroom, 2522, South Africa

Measurements made with the Voyager 1 spacecraft indicate that significant levels of compressive fluctuations exist in the so-called inner heliosheath, i.e. the region between the solar wind termination shock and the heliopause. Here we extend previous studies of the mirror-mode instability to the whole inner heliosheath. Employing quasilinear theory combined with results from a global magnetohydrodynamic model of the heliosphere allows for a computation of the time evolution of the temperature anisotropy and the energy density of the magnetic fluctuations related to the mirror mode. We demonstrate the likely presence of the latter in the inner heliosheath. Furthermore, we compute the associated, locally generated density fluctuations. The results can serve as inputs for future models of the transport of compressible fluctuations in this outermost region of the heliosphere.

Invited Talk EP 12.4 Fri 12:00 EP-H1

Solar Orbiter: two years of operations and first results — •Frederic Schuller, Alexander Warmuth, and Gottfried Mann — Leibniz Institute for Astrophysics (AIP) Potsdam, Germany

The Solar Orbiter spacecraft was launched in February 2020 and will remain the most significant observatory for solar physics research in the next decade. During the cruise phase, which ended in November 2021, several crucial activities took place, starting from the commissioning of the various instruments until the testing and validation of all possible observing modes. We will provide an overview of the mission and describe the regular operations, focussing on the day-to-day work of the STIX instrument team. Then, we will highlight some technical improvements that were achieved during the early phase of the mission. Finally, we will briefly present initial scientific results obtained so far, whereas the nominal phase has only just started.

EP 12.5 Fri 12:30 EP-H1

MHD avalanches in truly curved coronal arcades: proliferation and heating — •Jack Reid[1], James Threlfall[2], and Alan W. Hood[1] — [1]University of St Andrews, St Andrews, Fife, United Kingdom — [2]Abertay University, Dundee, United Kingdom

MHD avalanches involve small, narrowly localized instabilities spreading across neighbouring areas in a magnetic field. Cumulatively, many small events release vast amounts of stored energy. Straight cylindrical flux tubes are easily modelled, between two parallel planes, and can support such an avalanche: one unstable flux tube causes instability to proliferate, via magnetic reconnection, and an ongoing chain of like events. True coronal loops, however, visibly curve between footpoints on the same solar surface. With 3D MHD simulations, we verify the viability of MHD avalanches in the realistic, curved geometry of an arcade. MHD avalanches thus amplify instability in strong astrophysical magnetic fields and disturb wide regions of plasma. Contrasting with the behaviour of straight cylindrical models, a modified ideal MHD kink mode occurs, more readily and preferentially upwards. Instability spreads over a region far wider than the original flux tubes and their footpoints. Sustained heating is produced in a series of 'nanoflares', collectively contributing substantially to coronal heating. Overwhelmingly, viscous heating dominates, generated in shocks and jets produced by individual small events. Reconnection is not the greatest contributor to heating, but rather facilitates those processes that are. Localized and impulsive, heating shows no strong spatial preference, except a modest bias away from footpoints, towards the apex.

EP 12.6 Fri 12:45 EP-H1

Quasi-discontinuous solar wind models — •Lukas Westrich — Institut für theoretische Physik IV, Ruhr-Universität Bochum, Deutschland

Recently Shergelashvili et al. (2020) developed a new class of discontinuous solar wind solutions. They considered a case of quasi-adiabatic radial expansion with a jump in the flow velocity, density, and temperature but a continuous Mach number at the critical point and derived analytical solutions. Therefore, they proposed a localized external heating source without actual modeling. After a brief discussion of this concept, I will present continuous numerical solutions, more similar to the classical Parker solar wind model, but with quasi-adiabatic radial expansion with an explicitly formulated localized heating source. This kind of solutions can reproduce the analytically derived solutions without discontinuous jumps in the physical properties.

EP 12.7 Fri 13:00 EP-H1

Solar Surface Stereoscopy with Solar Orbiter's Polarimetric Helioseismic Imager — •Amanda Romero Avila, Bernd Inhester, Johann Hirzberger, and Sami Solanki — Max Planck Institute for Solar System Research

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

EP 12.8 Fri 13:15 EP-H1

A new global nonlinear force-free coronal magnetic-field extrapolation code implemented on a Yin Yang grid — •Argiris Koumtzis and Thomas Wiegelmann — Max Planck Institute for Solar System Research

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

EP 12.9 Fri 13:30 EP-H1

Automatic computation of magneto-hydro-static equilibria from magnetograms and EUV-images — •Thomas Wiegelmann and Maria Madjarska — MPS, Göttingen

We present a newly developed tool that models the magnetic field in the solar atmosphere and matches individual field lines with observed structures with enhanced emission in EUV images. Presently, for quiet Sun regions, we can only measure the photospheric line-of-sight magnetic field, as accurate horizontal field measurements are not available. The photospheric magnetic-field measurements are extrapolated into the upper photosphere, chromosphere and corona with a magneto-hydro-static model. Free model parameters are then optimized with a downhill simplex method by comparing magnetic field lines quantitatively with the enhanced emission of various structures recorded in EUV images. The tool can be employed to obtain the magnetic and plasma properties of these structures above the photosphere. This could help to achieve a better understanding of the solar atmosphere and will help the constrain of the modelling of atmospheric structures.

EP 12.10 Fri 13:40 EP-H1

Coronal Magnetic Field Extrapolation Using a Specific Family of Analytical 3D Magnetohydrostatic Equilibria - Practical Aspects — •Lilli Nadol and Thomas Neukirch — University of St Andrews, Scotland, UK

With current observational methods it is not possible to determine the magnetic field in the solar corona accurately. Hence, coronal magnetic field models have to rely on extrapolation methods using photospheric magnetograms as boundary conditions. In recent years, due to the increased resolution of observations and the need to resolve non-forcefree lower regions of the solar atmosphere, there have been efforts to use magnetohydrostatic (MHS) field models instead of force-free extrapolation methods. Although numerical methods to calculate MHS solutions can deal with non-linear problems more accurately, analytical 3D MHS equilibria can also be used as a numerically "cheaper" method.

We discuss a family of analytical MHS equilibria that allows for a transition from a non-force-free to a force-free region. The solution involves hypergeometric functions. While routines for the calculation of these are available, this can affect the speed and accuracy of the calculations. We look into the asymptotic behaviour of this solution in order to approximate it through exponential functions to improve the numerical efficiency. We present an illustrative example by comparing field line profiles, density and pressure differences between the exact solutions and the asymptotic solution.

EP 12.11 Fri 13:50 EP-H1

Confined and Subsequent Full Flux Rope Eruption as a Model for Homolous Solar Events — Alshaimaa Hassanin[1], •Bernhard Kliem[2], Norbert Seehafer[2], and Tibor Török[3] — [1]Department of Astronomy, Space Science & Meteorology, Faculty of Science, University of Cairo, Egypt — [2]Institute of Physics and Astronomy, University of Potsdam, Germany — [3]Predictive Science Inc., San Diego, CA 92121, USA

We present the first numerical model of a sequence of a confined and a full eruption (i.e., a coronal mass ejection, CME). The first eruption results from the helical kink instability of a sufficiently twisted magnetic flux rope; it remains confined because the flux rope does not reach the critical height for onset of the torus instability. A two-step reconnection process reforms a flux rope with subcritical twist near the position of the original flux rope. The full eruption develops as a result of converging motions imposed at the photospheric boundary, which drive flux cancellation. In this process, a part of the positive and negative sunspot flux converge toward the polarity inversion line, reconnect, and cancel each other. Flux of the same amount as the canceled flux transfers to the flux rope, increasing its free magnetic energy. With sustained flux cancellation and the associated progressive weakening of the magnetic tension of the overlying flux, we find that a flux reduction of $\approx 9\%$ leads to the ejective eruption. These results demonstrate that homologous eruptions, eventually leading to a coronal mass ejection, can be driven by flux cancellation.