Extraterrestial Physics Division
Fachverband Extraterrestrische Physik (EP)

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Overview of Invited Talks and Sessions

(Lecture halls HSZ/0004 and ZEU/0160; Poster HSZ OG 1

Plenary Talk of the Extraterrestrial Physics Division

PV IV	Tue	9:00– 9:45	HSZ/AUDI	**Characterising exoplanet atmospheres with the Webb space telescope** — •Pierre-Olivier Lagage

Invited Talks

EP 1.1	Mon	10:45–11:15	HSZ/0004	**A Melting Probe for the Exploration of Subglacial Lakes within the TRIPLE project line** — •Mia Giang Do, Jan Audehm, Clemens Espe, Marco Feldmann, Gero Francke, Fabian Schöttler, Dirk Heinen, Stefan Kaiser, Andreas Nöll, Christopher Wiebusch, Yuting Ye, Simon Zierke
EP 2.1	Mon	16:15–16:45	ZEU/0160	**The exoplanet revolution: towards habitable worlds** — •Alexis Smith
EP 5.1	Wed	10:45–11:15	ZEU/0160	**New insights into the elusive magnetic processes operating in the solar corona with SolO/EUI** — •Lakshmi Pradeep Chitta
EP 5.3	Wed	11:30–12:00	ZEU/0160	**Studying solar flares with the X-ray telescope STIX during the cruise and early science phase of Solar Orbiter** — •Alexander Warmuth
EP 7.1	Wed	14:15–14:45	ZEU/0160	**Advances in energetic particle physics with Solar Orbiter & Parker Solar Probe** — •Robert F. Wimmer-Schweingruber, Javier Rodriguez-Pacheco, George C. Ho, Robert A. Allen, Raul Gomez-Herrero, and the Solar Orbiter EPD Team
EP 7.3	Wed	15:00–15:30	ZEU/0160	**New Insights in Simulations of SEP Events with the PARADISE+ICARUS Model** — •Edin Husidic, Nicolas Wijsen, Tinatin Baratashvili, Stefaan Poedts, Rami Vainio
EP 8.1	Wed	16:00–16:30	ZEU/0160	**Precision measurements of cosmic ray fluxes from AMS-02 with a daily time resolution** — •Stefan Schael
EP 10.1	Thu	11:00–11:45	ZEU/0160	**Arne-Richter Lecture: From nonthermal plasmaastrophysics to modeling of pandemic outbreaks** — •Reinhard Schlickeiser
EP 11.1	Thu	14:00–14:30	ZEU/0160	**Energetic Particle Precipitation reflected in the Global Secondary Ozone Distribution** — •Jia Jia, Lisa E. Murberg, Tiril Løvset, Yvan J. Orsolini, Patrick J. Espy, Jude Salinas, Jae N. Lee, Dong Wu, Jiarong Zhang
EP 12.1	Thu	15:45–16:15	ZEU/0160	**Ultra-relativistic Electrons in the Earth's Van Allen Radiation Belts** — •Yuri Y. Shprits, Hayley Allison, Nikita Aseev, Dedong Wang, Alexander Drozdov
EP 13.1	Thu	17:30–18:00	ZEU/0160	**Time-dependent data analysis of a blazar flare** — •Maximilian Albrecht, Felix Spanier
EP 14.1	Fri	11:00–11:30	HSZ/0004	**Unveiling the secrets of hot, massive stars with modern stellar atmosphere models** — •Andreas A C Sander

Invited Talks of the joint Symposium Strange Clouds – from the Earth to Exoplanets (SYSC)

See SYSC for the full program of the symposium.

SYSC 1.1	Tue	11:00–11:20	HSZ/0004	**Not all clouds are created equal – strange clouds in our solar system** — •Thomas Leisner
SYSC 1.2	Tue	11:20–11:45	HSZ/0004	**Clouds to the Edge of Space** — •Gerd Baumgarten, Ronald Eixmann, Jens Fiedler, Michael Gerding, Mykhaylo Grygalashvyly, Franz-Josef Lübken, Ashique Vellalassery, Christian von Savigny, Robin Wing
SYSC 1.3	Tue	11:45–12:10	HSZ/0004	**The dynamic clouds of Venus** — •Javier Peralta
SYSC 1.4	Tue	12:10–12:35	HSZ/0004	**Observational constraints of exoplanet clouds** — •Nicolas Iro
SYSC 1.5	Tue	12:35–13:00	HSZ/0004	**Gemstone clouds in JWST target exoplanets** — •Dominic Samra, Christiane Helling

Sessions

EP 1.1–1.8	Mon	10:45–13:00	HSZ/0004	**Planets and small Objects**
EP 2.1–2.5	Mon	16:15–17:45	ZEU/0160	**Exoplanets and Astrobiology**
EP 3.1–3.5	Tue	16:45–18:00	ZEU/0160	**Clouds in Planetary Atmospheres (joint session EP/UP)**
EP 4.1–4.4	Tue	18:00–19:00	ZEU/0160	**Planetary atmospheres**
EP 5.1–5.6	Wed	10:45–12:45	ZEU/0160	**Sun and heliosphere I**
EP 6	Wed	13:00–14:00	ZEU/0160	**Members' Assembly**
EP 7.1–7.4	Wed	14:15–15:45	ZEU/0160	**Sun and heliosphere II**
EP 8.1–8.4	Wed	16:00–17:15	ZEU/0160	**Sun and heliosphere III**
EP 9.1–9.20	Wed	17:30–19:00	HSZ OG1	**Poster**
EP 10.1–10.6	Thu	11:00–13:00	ZEU/0160	**Astrophysics: Cosmic Rays and Galaxies I**
EP 11.1–11.5	Thu	14:00–15:30	ZEU/0160	**Near-Earth Space I**
EP 12.1–12.5	Thu	15:45–17:15	ZEU/0160	**Near-Earth Space II**
EP 13.1–13.5	Thu	17:30–19:00	ZEU/0160	**Astrophysics: Galaxies II**
EP 14.1–14.7	Fri	11:00–13:00	HSZ/0004	**Astrophysics: Stellar Astrophysics**
EP 15.1–15.6	Fri	14:00–15:30	HSZ/0004	**Astrophysics: Cosmology**

Members' Assembly of the Extraterrestial Physics Division

Wednesday 13:00–14:00 ZEU/0160

EP 1: Planets and small Objects

Time: Monday 10:45–13:00 Location: HSZ/0004

Invited Talk EP 1.1 Mon 10:45 HSZ/0004

A Melting Probe for the Exploration of Subglacial Lakes within the TRIPLE project line — •Mia Giang Do[1], Jan Audehm[1], Clemens Espe[2], Marco Feldmann[2], Gero Francke[2], Fabian Schöttler[2], Dirk Heinen[1], Stefan Kaiser[1], Andreas Nöll[1], Christopher Wiebusch[1], Yuting Ye[1], and Simon Zierke[1] — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]GSI - Gesellschaft für Systementwicklung und Instrumentierung mbH, Aachen, Germany

Jupiter's moon Europa is a prime candidate for the search for extraterrestrial life in the solar system. Previous observations suggest the existence of a global ocean beneath the moon's icy shell. To explore the hidden water reservoir, future missions will need to penetrate the massive ice layer. The development of key technologies for such a mission is the subject of the TRIPLE project line (Technologies for Rapid Ice Penetration and Subglacial Lake Exploration) initiated by the German Space Agency at DLR. Within TRIPLE, an electrothermal probe will be used as the carrier system for transporting scientific payloads. A terrestrial analogous demonstration of the system is planned in the Dome C region in Antarctica. With an expected subglacial lake underneath a 4 km thick icy shell, Dome C does not only provide an ideal test site, but also a great challenge for TRIPLE. To fulfill the mission, it is mandatory for the melting probe to be retrievable and capable of releasing and recapturing payloads at the ice-water interface. This talk will focus on the technological challenges of the melting probe and present the latest terrestrial test campaigns.

EP 1.2 Mon 11:15 HSZ/0004

Material properties of matter in Saturn's interior from ab initio simulations — •Martin Preising[1], Martin French[1], Christopher Mankovich[2], Francois Soubiran[3], and Ronald Redmer[1] — [1]Universität Rostock, Rostock, Germany — [2]California Institute of Technology, Pasadena, USA — [3]Commissariat à l'énergie atomique et aux énergies alternatives, Arpajon, France

Calculation of material properties from ab inito simulations along Jupiter [1] and Brown Dwarf adiabats [2] have been subject of earlier studies. However, accurate models of Saturn's interior are still very challenging. A recent study by Mankovich and Fortney on Jupiter and Saturn models was based on a single physical model [3] which predicts a strongly differentiated helium distribution in Saturn's deep interior, resulting in a helium-rich shell above a diffuse core.

We focus on the calculation of material properties of matter at P-T conditions along the Saturn model proposed by Mankovich and Fortney. We present results on thermodynamic and transport properties of a hydrogen-helium-water mixture that closely resembles the element distribution of the Saturn model. We discuss implications of the results on our understanding of Saturn's interior and evolution.

[1] French et al., Astrophys. J. Suppl. Ser., 202, 5 (2012). [2] Becker et al., Astron. J., 156, 149 (2018). [3] Mankovich and Fortney, Astrophys. J., 889, 51 (2020). [4] Monserrat et al., Phys. Rev. Lett., 112, 055504 (2014). [5] Preising and Redmer, Phys. Rev. B, 102, 224107 (2020).

EP 1.3 Mon 11:30 HSZ/0004

The interior and thermo-chemical evolution of Mars — •Ana-Catalina Plesa and Doris Breuer — DLR, Institute of Planetary Research, Germany

The observational data currently available about Mars provide us with the opportunity to study the interior and thermochemical evolution of the planet with unprecedented detail. This includes geological and mineralogical datasets, gravity and topography data, magnetic field data, and most recently, seismic data from the InSight mission. In this talk, we will show what we have already learned about the interior and thermochemical evolution of Mars, and where there are still open (new) questions - especially through the analysis of the new data from InSight - for the geodynamic reconstruction of the Martian interior.

EP 1.4 Mon 11:45 HSZ/0004

On the propagation of linear and nonlinear waves in the Venusian ionosphere — •Horst Fichtner[1], Alaa Fayad[1,2], Samy Salem[1,2], Marian Lazar[1,3], Waled Moslem[1,2], and Sara Morsi[1,2,4] — [1]Institut für Theoretische Physik IV, Ruhr-Universität Bochum, 44780 Bochum, Germany — [2]Department of Physics, Faculty of Science, Port Said University, Port Said 42521, Egypt — [3]Centre for mathematical Plasma Astrophysics, KU Leuven, 3001 Leuven, Belgium — [4]The British University in Egypt, El-Shorouk City, Cairo, Egypt

The ionosphere of Venus represents, partly due to its interaction with the solar wind, a dynamic plasma environment that hosts a variety of plasma waves. These waves play potentially significant roles for the structure of this region, for the atmospheric erosion, or for the transport and acceleration of energetic particles. In the presentation both linear and nonlinear waves are studied within the framework of (multi-species) hydrodynamics and magnetohydrodynamics, which allows, depending on the model assumptions, to analyze their dispersion in a linearizing approach and their nonlinear dynamics using a perturbative approach. Within the hydrodynamic treatment also the ion outflow from the Venusian atmosphere can be investigated.

EP 1.5 Mon 12:00 HSZ/0004

Conformal mapping for the planetary bow shock and magnetopause studies — •Yasuhito Narita[1], Simon Toepfer[2], and Daniel Schmid[1] — [1]Space Research Institute, Austrian Academy of Sciences, Graz, Austria — [2]Institut für Theoretische Physik, Technische Universität Braunschweig, Braunschweig, Germany

The concept of conformal mapping is introduced to the planetary magnetospheric research as a useful tool to characterize the bow shock and magnetopause geometry and to directly compare the in-situ measurements of magnetic field and plasma flow with the theoretical models. Various models of the planetary bow shock and magnetopause can be extended from the real-number expression to the conformal mapping in the complex plane. By doing so, the spatial domains around the bow shock and magnetopause are easily expressed in orthogonal curvilinear coordinates. In particular, the parabolic bow shock and the tail-elongated magnetopause are found to be conformally mapped using only elementary analytic expressions. Conformal mapping opens the door to construct a high-precision steady-state model of the magnetic field and plasma flow in the planetary magnetosheath region by transforming the Kobel-Flueckiger scalar potential, the exact solution of Laplace equation in parabolic magnetosheath coordinates, to arbitrary two-dimensional bow shock and magnetopause shapes. Such a model will significantly ease the interpretation of magnetic field or plasma data in the planetary missions, as one obtains the global picture of bow shock, magnetopause, and magnetosheath from the model either from the measurements or from the given solar wind condition.

EP 1.6 Mon 12:15 HSZ/0004

Mirror Modes in the Hermean Magnetosheath — •Martin Volwerk[1], Charlotte Goetz[2], Daniel Heyner[3], Tomas Karlsson[4], Ferdinand Plaschke[3], Daniel Schmid[1], and Cyril Simon Wedlund[1] — [1]Space Research Institute, Austrian Academy of Sciences, Graz, Austria — [2]Northumbria University, Newcastle upon Tyne, United Kingdom — [3]Institut für Geophysik und extraterrestrische Physik Technische Universität Braunschweig, Germany — [4]Space and Plasma Physics School of Electrical Engineering and Computer Science KTH Royal Institute of Technology Stockholm. Sweden

Mirror modes are quasi-stationary structures in the plasma frame, consisting of a train of magnetic depressions combined with plasma density enhancements. They are created by a temperature asymmetry in the plasma, where the perpendicular temperature (with respect to the magnetic field) is higher than the parallel temperature. These structures are ubiquitous in planetary magnetosheaths, and have been detected at Venus, Earth, Mars, Jupiter and even at comets. Similar structures to mirror modes are magnetic holes, usually born in the solar wind upstream of the shock and can be transported into the magnetosheath (Karlsson et al., 2021). Here we study magnetic field data during the orbital phase of the MESSENGER mission at Mercury to identify mirror mode-like structures with a magnetic-field-only method. Properties of mirror mode structures will be compared to those of isolated magnetic holes observed in the magnetosheath earlier, to investigate if they are related phenomena

EP 1.7 Mon 12:30 HSZ/0004

Deformed bow shock and magnetic depression: Lessons

from BepiColombo's flyby-2 at Mercury — •Daniel Schmid[1], David Fischer[1], Werner Magnes[1], Yasuhito Narita[1], Martin Volwerk[1], Wolfgang Baumjohann[1], Ayako Matsuoka[2], Uli Auster[3], Ingo Richter[3], Daniel Heyner[3], Ferdinand Plaschke[3], and Rumi Nakamura[1] — [1]Istitut für Weltraumforschung (IWF) Graz, Österreichische Akademie der Wissenschaften (OeAW) — [2]World Data Center for Geomagnetism, Kyoto University — [3]Institut für Geophysik und Extraterrestrische Physik, Technische Universität Braunschweig

Understanding Mercury's magnetospheric structure remains a challenge due to the planet's proximity to the Sun. The magnetic field data from BepiColombo's flyby-2 at Mercury in June 2022 allows us to study the magnetosphere and its space environment in-situ. The bow shock crossing analysis reveals that the shock normal direction is significantly deformed during the inbound crossing and is comforting to the steady-state bow shock shape during the outbound crossing. The magnetosphere crossing analysis reveals a short-time magnetic field depression in the midnight sector before the closest approach, indicating either occurrence of a transient event or crossing of a current layer separating the dipolar from the tail-field region. The BepiColombo flyby-2 magnetic field data analysis shows that Mercury's magnetosphere is highly dynamic and identification of transient events from the quasi-steady state of the magnetosphere plays a crucial role in constructing the magnetospheric structure from the magnetic field data.

EP 1.8 Mon 12:45 HSZ/0004

Analysis of IMF penetration into Mercury's Magnetosphere — •Kristin Pump, Daniel Heyner, and Ferdinand Plaschke — TU Braunschweig, IGEP, Mendelssohnstraße 3, 38106 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. A semi-empirical magnetospheric model can capture the large-scale magnetospheric structures. Using the residuals between in-situ data and the model prediction we further seek to improve our understanding of the Hermean magnetosphere. To first order the magnetopause completely separates the magnetosphere from the magnetosheath and thus no magnetic field may penetrate this boundary. In reality, the magnetosheath field may diffuse across the very thin boundary within a finite time. Here, we investigate this penetration and compare the different interplanetary field (IMF) components by their ability to enter into Mercury's Magnetosphere. For this, we use in-situ MESSENGER magnetic field data to estimate the IMF for the time frame with the probe located inside the magnetosphere. The amount of penetration is found by least-square fitting to magnetospheric model results. First statistical results indicate that the penetration is stronger under southward IMF conditions.

EP 2: Exoplanets and Astrobiology

Time: Monday 16:15–17:45 Location: ZEU/0160

Invited Talk EP 2.1 Mon 16:15 ZEU/0160

The exoplanet revolution: towards habitable worlds — •Alexis Smith — Institut für Planetenforschung, Deutsches Zentrum für Luft- und Raumfahrt, Berlin

In the nearly 30 years since the discovery of the first exoplanets, planet detection has continued to accelerate, driven in large part by the space-based transit missions Kepler/K2 and TESS; there are now more than 5000 confirmed exoplanets. These detections have enabled insights into the demographics of the exoplanet population, and hence into the formation and migration processes that sculpted the planetary systems that we observe today. As we begin to place our own planetary system into a Galactic context, there have been innumerable surprises such as the discovery that the most common type of planet is not represented in our Solar System. Meanwhile, bright transiting systems, such as those discovered by TESS, are increasingly amenable to atmospheric characterisation with existing ground-based facilities, as well as with JWST. In the near future, the ESA Ariel mission and the ground-based ELTs will continue to expand the available parameter for atmospheric exploration. Finally, ESA's upcoming PLATO mission will enhance our planet detection abilities, putting Earth-like planets in reach for the first time.

EP 2.2 Mon 16:45 ZEU/0160

Habitability inside astrospheres — •Klaus Scherer[1], Konstantin Herbst[2], Dominik J. Bomans[3], N. Eugene Engelbrecht[4], Stefan .E.S. Ferrerira[4], Lennart Baalmann[5], Frederiic Effenberger[1], and Jen Kleimann[1] — [1]Institut für Theoretische Physik IV, Ruhr-Universität Bochum, Germany — [2]Institut für Experimentelle and Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Germany — [3]Astronomisches Institut, Ruhr-Universität Bochum, Germany — [4]Centre for Space Research, North-West University, Potchefstroom, South Africa — [5]Institute for Particle and Astroparticle Physics, ETH Zürich, Switzerland

The habitable planets around a host star are not only influenced by the stellar wind or flare activity, but are also embedded in the interstellar environment, which can also influence these planets and their atmospheres. We will show that, for certain classes of astrospheres, the inflow of the neutrals on the top of an exoplanetary atmosphere can be large. This is done by modelling the interaction between the stellar wind and the interstellar medium using a two fluid MHD model. Moreover, such an 3D MHD simulation will also allow us to study the modulation of galactic cosmic rays in 3D, incorporating a turbulence transport model, so that the diffusion coefficients and the drift velocities can be modelled as far as possible from first principles. We will also discuss the latter point.

EP 2.3 Mon 17:00 ZEU/0160

Examining the orbital decay targets KELT-9 b, KELT-16 b, and WASP-4 b, and the transit-timing variations of HD 97658 b — •Jan-Vincent Harre — DLR - Institute of Planetary Research, Berlin, Germany

Tidal orbital decay is suspected to occur for hot Jupiters in particular, with the only observationally confirmed case of this being WASP-12 b. By examining this effect, information on the properties of the host star can be obtained using the so-called stellar modified tidal quality factor $Q_\star$', which describes the efficiency of the planetary kinetic energy dissipation within the star. In this study, we aim to improve constraints on the tidal decay of the KELT-9, KELT-16, and WASP-4 systems, making it possible to constrain the $Q_\star$' value for each star. In addition, we aim to test the existence of the TTVs in the HD 97658 system, which previously favoured a quadratic trend with increasing orbital period. Making use of newly acquired photometric observations from CHEOPS and TESS, combined with archival data, we fit three models to the data, namely a constant-period model, an orbital-decay model, and an apsidal-precession model. We find that the KELT-9 system is best described by an apsidal-precession model for now, with an orbital decay trend at over 2σ being a possibility as well. A Keplerian orbit model provides the best fit to the transit timings of KELT-16 b because of the scatter and scale of their error bars. The WASP-4 system is best represented by an orbital decay model at a 5σ significance, although apsidal precession cannot be ruled out. For HD 97658 b, we find no conclusive evidence for the suspected trend in the data.

EP 2.4 Mon 17:15 ZEU/0160

Deciphering Dayglow as Biosignature of Planet Earth — •Katharina Uhlmannsiek[1], Michael Sterzik[1], Claudia Emde[2], and Stefano Bagnulo[3] — [1]ESO, Garching, Germany — [2]Institute for Meteorology LMU, München, Germany — [3]Armagh Observatory, Belfast, UK

Biosignatures in the near-infrared spectrum of Earth's atmosphere include the simultaneous presence of H2O, O2 and CH4 molecular absorption bands, but also abundant skyline emission features caused by chemo-photolytic reaction networks of Oxygen in the upper atmosphere such as OH. New infrared spectra of Earthshine were obtained with the CRIRES+ instrument at the VLT and achieve a high spectral resolution of R > 100 000. Thus, narrowband features of day- and nightglow emission (e.g. OH, O2) can be resolved. We compare airglow lines caused by different mechanisms, and try to discern day- and nightglow from contaminating atmospheric transmission. Earthshine spectra consist of the spatially integrated light of the illuminated Earth and Earth's atmosphere and are therefore considered analogous to direct observations of exoplanets. Hence, tracing biosignatures in our high-resolution CRIRES+ observations of Earthshine opens a novel window for the detection of biosignatures of Earth-like planets.

EP 2.5 Mon 17:30 ZEU/0160

Origin of life - RNA viruses first? — •Karin Moelling — Inst Med Mikrobiol Uni Zürich Schweiz

The first biomolecules are replicating non-coding RNA enzymes, ribozymes, which can cleave and join and evolve. The ribozymes are the active component for protein synthesis, ribosomes are ribozymes. They are also designated as viroids. RNA is essential at many most prominent steps in metabolism, on planet Earth, as primers, as chief regulators (circRNA), in sperm for non-Mendelian transgenerational inheritance, for silencing, defense , evolution etc. RNA can do it all. It is unstable and sensitive and needs protection. The most versatile living entities are the archaea, which can cope with extreme environmental conditions, and were named extremophiles. They are very complicated and specialized to Earth conditions, they are innovative but evolution of metabolic pathways takes time. What are the most likely or unlikely conditions on Planet Earth, which allow to extrapolate to possible extraterrestric living conditions. The conflict is either a unique earth versus astronomical numbers of exoplanets. (Moelling K: Viren die Supermacht des Lebens (C.H. Beck Press) or "Viruses, more Friends than Foes (WSPress)).

EP 3: Clouds in Planetary Atmospheres (joint session EP/UP)

Time: Tuesday 16:45–18:00 Location: ZEU/0160

EP 3.1 Tue 16:45 ZEU/0160

Wellen und Wolken in der Atmosphäre über den südlichen Anden gemessen mit einem Rayleigh-Lidar — •Natalie Kaifler, Bernd Kaifler, Andreas Dörnbrack und Markus Rapp — Deutsches Zentrum für Luft- und Raumfahrt e.V., Institut für Physik der Atmosphäre

Das CORAL-Lidar misst seit November 2017 in Tierra del Fuego, Argentinien (54°S) die Temperatur der Atmosphäre bis in 100 km Höhe. In der Stratosphäre treten über den südlichen Anden durch Gebirgswellen verursachte Temperaturstörungen von über 20 K Amplitude auf. In den kalten Phasen der Wellen können auf diese Weise polare Stratosphärenwolken auch in mittleren Breiten entstehen. In größeren Höhen, am oberen Rand der Mesosphäre, ist die Temperatur im Sommer kalt genug für die Bildung von Eiswolken, den sogenannten leuchtenden Nachtwolken. Sie werden durch die Gezeitenwinde beeinflusst, sind stark durch Schwerewellen moduliert, und treten in der Südhemisphäre nicht seltener auf als in der Nordhemisphäre, was man aufgrund der höheren Hintergrundtemperatur der südlichen polaren Mesosphäre erwarten könnte. Wir zeigen eine Übersicht und ausgewählte Beobachtungen von Wellen und Wolken in der mittleren Atmosphäre aus mehr als fünf Jahren Lidar-Messungen.

EP 3.2 Tue 17:00 ZEU/0160

Preferential adsorption of para and ortho water molecules on charged nanoparticles in planetary ice clouds — •Johanna Weidelt[1], Thomas Dresch[2], Denis Duft[2], and Thomas Leisner[2,3] — [1]Ultrafast Science Research Unit, University of Bielefeld, Germany — [2]Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology, Germany — [3]Institute of Environmental Physics, University of Heidelberg, Germany

In the Earth mesopause, nanometer-size singly charged particles form by condensation of evaporated meteorite material. They exhibit an enhanced water adsorption cross section due to the strong charge-dipole-interaction. In this work, we study how the nuclear spin state of water molecules affects this enhancement and whether there are conditions that could lead to the formation of spin-polarized ice. Due to symmetry constraints on the total molecular wavefunction, ortho (proton spins parallel) and para (spins antiparallel) water occupy different rotational states, resulting in a different average dipole orientation in electric fields. Therefore, we expect ortho and para water to exhibit distinct adsorption enhancement factors onto charged nanoparticles. Based on Stark-shifts of individual rotational states of water, average dipole orientations of a molecular ensemble and the resulting collision cross section was calculated for various temperatures and particle sizes. We found that in the mesosphere of the Earth (T~150K) the adsorption enhancement of ortho- and para- water is approximately equal while at lower temperatures prevailing around ice giant planets and their moons, significant spin polarizations up to 15% occur.

EP 3.3 Tue 17:15 ZEU/0160

On the colour of noctilucent clouds — •Christian von Savigny[1], Anna Lange[1], Gerd Baumgarten[2], and Alexei Rozanov[3] — [1]Institute of Phyics, University of Greifswald, Greifswald, Germany — [2]Leibniz Institute of Atmospheric Physics, Kühlungsborn, Germany — [3]Institute of Environmental Physics, University of Bremen, Bremen, Germany

Noctilucent clouds, also known as polar mesospheric clouds, are a polar summer mesopause phenomenon and they are typically characterised by a silvery-blue or pale blue colour. In this contribution, we investigate the reasons for this colour using the radiative transfer model SCIATRAN in combination with the CIE (International Commission on Illumination) colour-matching functions in order to the determine the resulting colour impression in an objective way. Different processes and parameters potentially affecting the colour of NLCs are investigated, i.e. the size of the NLC particles, the abundance of middle atmospheric O3 and the importance of multiply scattered solar radiation. We confirm earlier studies indicating that absorption of solar radiation in the O3 Chappuis bands can have a significant effect on the colour of the NLCs. It is, however, found that for sufficiently large NLC optical depths O3 plays only a minor role for the blueish colour. The simulations also show that the size of NLC particles affects the colour of the clouds. Cloud particles of unrealistically large sizes can lead to a reddish colour. Furthermore, the simulations show that the contribution of multiple scattering to the total scattering is only of minor importance, providing additional justification for the earlier studies on this topic, which were all based on the single-scattering approximation.

EP 3.4 Tue 17:30 ZEU/0160

Exoplanetary clouds: The potential of high-precision polarimetry — •Moritz Lietzow and Sebastian Wolf — Institute of Theoretical Physics and Astrophysics, Kiel University, Germany

The reflected flux from planets is polarized due to scattering in their atmosphere. While polarimetry is used to study objects in the Solar System, it has also been proposed for detection and characterization of extrasolar planets. In particular, the reflected polarized flux depends not only on the planetary phase angle and observed wavelength, but also on the atmospheric composition, allowing to distinguish between various cloud compositions. Given the accuracy of existing high-precision polarimeters, scattered light polarimetry indeed has the potential to become a powerful tool to characterize exoplanetary atmospheres. First measurements of planet-induced polarization were reported during recent years. To provide the basis for theoretical studies and the interpretation of dedicated polarization measurements, we developed a radiative transfer simulation software that contains all relevant continuum polarization mechanisms for the comprehensive analysis of the polarized flux resulting from the scattering in the atmosphere, on the surface, and in the local planetary environment. In addition, we investigated the impact of the cloud composition and exoplanetary rings on the scattered light polarization.

EP 3.5 Tue 17:45 ZEU/0160

Retrieval of cloud properties using spectropolarimetric simulations of Earthshine — •Orsolya Pari[1], Claudia Emde[1], Michael Sterzik[2], and Mihail Manev[1] — [1]Ludwig-Maximilians-Universität, München, Germany — [2]European Southern Observatory, Garching bei München, Germany

In order to be able to interpret future observations of the atmospheres of Earth-like planets and detect signatures of life, it is important to understand Earth's atmospheric and surface properties. Observations of Earthshine, which is sunlight scattered by Earth to the Moon, and then reflected back to Earth, make it possible to study Earth as an exoplanet.

We use the Monte Carlo radiative transfer model MYSTIC to simulate polarized spectra in the atmosphere of the Earth for Ocean and Lambertian surfaces. A water or an ice cloud layer is included and we vary the cloud parameters (cloud altitude, cloud optical thickness, effective droplet radius).

The focus is on the $O_2 - A$ and H_2O bands, where the degree of polarization can be higher or lower than the adjacent continuum. To quantify this behavior we use the equivalent width, which is the area in the passband between the absorption line and the simulated spectrum without absorption across a specific spectral region.

We find that the equivalent width is highly sensitive to cloud altitude and cloud optical thickness.The simulations are compared to the observations of Earthshine obtained by FORS2 at the VLT for different Sun-Earth-Moon phase angles.

EP 4: Planetary atmospheres

Time: Tuesday 18:00–19:00 Location: ZEU/0160

EP 4.1 Tue 18:00 ZEU/0160

Jupiter moon Ganymede's atmosphere observed with the Hubble Space Telescope — •Lorenz Roth[1], Gregorio Marchesini[1], Tracy Becker[2], Jens Hoeijmakers[3], Philippa Molyneux[2], Kurt Retherford[2], Joachim Saur[4], Shane Carberry Mogan[5], and Jamey Szalay[6] — [1]KTH Royal Institute of Technology, Stockholm Sweden / ESO Garching bei München — [2]Southwest Research Institute, San Antonio, TX, USA — [3]Lund University, Sweden — [4]Universität zu Köln — [5]University of California, Berkeley, CA, USA — [6]Princeton University, Princeton, NJ, USA

Jupiter's moon Ganymede is the largest moon in the Solar System and the only one that generates its own magnetic field in the interior. Ganymede also possesses a tenuous water-based atmosphere, produced by the solar and Jovian plasma irradiation of its icy surface. Here we report results from far-ultraviolet observations by the Hubble Space Telescope of Ganymede transiting across the planet's dayside hemisphere. Within a targeted campaign on 9 September 2021 two exposures were taken during one transit passage to probe for attenuation of Jupiter's hydrogen Lyman-α dayglow above the moon limb. The background dayglow is slightly attenuated over an extended region around Ganymede. The obtained vertical H column densities are consistent with previous results. Constraining angular variability around Ganymede's disk, we derive an upper limit on a local H2O column density such as could arise from outgassing plumes in regions near the observed moon limb.

EP 4.2 Tue 18:15 ZEU/0160

Investigation of the Influence of Stellar Particle Events and Galactic Cosmic Rays on the Atmosphere of TRAPPIST-1e — •Andreas Bartenschlager[1], Miriam Sinnhuber[1], John Lee Grenfell[2], Benjamin Taysum[2], Fabian Wunderlich[2], and Konstantin Herbst[3] — [1]Karlsruher Institute of Technology, Germany — [2]German Aerospace Center, Berlin, Germany — [3]University of Kiel, Germany

The launch of the James Webb Space Telescope (JWST) in December 2021 opens up the possibility of studying the composition of exoplanetary atmospheres in habitable zones in the near future. We investigate the influence of stellar energetic particles (SEPs) on the atmospheric chemistry of exoplanets around a very active M-star TRAPPIST-1, using the ion chemistry model ExoTIC. We perform model experiments with different N_2 or CO_2 dominated atmospheres, depending on the initial CO_2 partial pressure, as well as humid and dry conditions, taking into account the ionization rates for such events. A further specification is the distinction between dead and alive atmospheres, whose atmospheric composition is characterized by a lower or higher oxygen fraction in the initial conditions. Within ExoTIC we calculate the impact of the ionization events on these atmospheres both as a single and as a series of events with different strengths. Preliminary results show a significant impact of SEP events on the chemical composition of the atmosphere, including biosignatures such as O_3. The strength of these impacts depends on the starting atmospheres' relative oxygen, nitrogen and water vapour content.

EP 4.3 Tue 18:30 ZEU/0160

Simulating exoplanetary atmospheres in the laboratory: comparing experimental data with output from an atmospheric model — •Florence Hofmann[1], Paul Mabey[1], Egemen Yüzbasi[1,2], John Lee Grenfell[2], Heike Rauer[1,2,3], and Andreas Elsaesser[1] — [1]Freie Universitaet Berlin, Germany — [2]Institute for Planetary Research, Berlin, Germany — [3]Berlin University of Technology, Germany

Since the discovery of the first exoplanet, several thousand have have been found including some rocky planets in the habitable zone. The new generation of instruments such as the James Webb Space Telescope will search for spectroscopic signals of atmospheric biosignatures on these worlds. Correctly interpreting such signals requires atmospheric models with consistent and flexible climate and chemical modules over a wide parameter range. With our new Planetary Simulation Chamber at FU Berlin, we are capable of simulating a large set of atmospheric parameters for Earth-like planets in the laboratory. We are able to vary the incoming spectra to simulate the photochemical and climate effects of Earth-like planets orbiting different stars. Many telescopes operate in the VIS/NIR range that corresponds to the fingerprint regions of interesting organic molecules. Our facility allows continuous spectroscopic in-situ monitoring of samples in the UV/IR region and simultaneous mass spectroscopic analysis. In collaboration with our partners at the DLR institute for planetary research, we compare experimental results from our chamber with output from their climate-chemistry model 1D-TERRA.

EP 4.4 Tue 18:45 ZEU/0160

Simulating Atmospheric Climate and Chemical Responses on a hypothetical, Earthlike Planet orbiting AD Leonis — •Julian Graupner[1], John Lee Grenfell[1], Hella Garny[2], Anna Goetz[2], and Heike Rauer[1,3,4] — [1]Department of Extrasolar Planets and Atmospheres, Instiute of Planetary Research, German Aerospace Centre (DLR), Berlin, Germany — [2]Department of Earth System Modelling, Institute for Atmospheric Physics, German Aerospace Centre (DLR), Oberpfaffenhofen-Wesling, Germany — [3]Centre for Astronomy and Astrophysics, Berlin Institute of Technology, Berlin, Germany — [4]Institute for Geological Science, Free University of Berlin, Berlin, Germany

Simulating a hypothetical Earth orbiting the active M-dwarf star AD Leonis is well-established since the stellar spectrum is well-characterized and there are numerous model studies in the literature. A long-term aim is to estimate the transport, climate and photochemical effects using a column climate-photochemical model loosely coupled with a parameterized 3D model. The column model is integrated over a range of latitudes which then generates a temperature map used as input for the 3D transport model. In the present study we report only results from the 1D model study for Earth placed around AD Leonis at an orbit where it receives the same instellation. Compared with previous column model studies we find that recent improvements in our climate and chemistry modules has led to modest changes in our simulated cold trap, hence water vapor abundances and also in the middle atmosphere ozone amount.

EP 5: Sun and heliosphere I

Time: Wednesday 10:45–12:45 Location: ZEU/0160

Invited Talk EP 5.1 Wed 10:45 ZEU/0160

New insights into the elusive magnetic processes operating in the solar corona with SolO/EUI — •Lakshmi Pradeep Chitta — Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077 Göttingen

The solar corona, million Kelvin hot outer atmosphere of the Sun, is governed by magnetic fields. Streams of charged particles continuously escape this hot atmosphere into the heliosphere as solar wind. Magnetic processes responsible for coronal heating and for powering the solar wind are a subject of active debate for over six decades. With its unprecedented high-resolution, high-cadence view of the Sun, the Extreme Ultraviolet Imager (EUI) onboard the Solar Orbiter mission is shedding new light on the elusive magnetic processes operating in the corona. At closest approach, EUI can provides data with a spatial resolution of about 200 km and a cadence of below 3 s. During the first science perihelion observing campaigns of Solar Orbiter, the EUI instrument imaged untangling of small-scale coronal magnetic braids through reconnection, and subsequent heating of plasma in some active region coronal loops. These observations suggest that magnetic reconnection in coronal loops might be operating on short timescales of a few 10 s and on spatial scales of a few 100 km. The EUI data also revealed ubiquitous high-speed reconnection-driven jets from coronal holes. These jets can channel sufficient heated material to sustain the solar wind mass flux. In this talk, we present these novel observations and discuss the role of magnetic reconnection in the heating of coronal plasma and in the driving of solar wind.

EP 5.2 Wed 11:15 ZEU/0160

Picoflares in the Quiet Solar Corona Observed by the Solar Orbiter — •Olena Podladchikova[1,2], Alexander Warmuth[1], Francis Verbeeck[3], Marco Velli[4], Susanna Parenti[5], Frederic Auchere[5], Astrid Veronig[6], Stefan Purkhart[6], Stefan Hofmeister[1], Udo Schuehle[7], Luca Teriaca[7], Aznar Cuadrado[7], Andrea Battaglia[8], Frederic Schuller[1], and Anik De Groof[9] — [1]AIP, Potsdam, Germany — [2]Kiev Polytechnic University, Ukraine — [3]ROB, Belgium — [4]UCLA, USA — [5]IAS, France — [6]University of Graz, Austria — [7]MPS, Germany — [8]ETH, Switzerland — [9]ESA, Madrid, Spain

On May 30, 2020, the Solar Orbiter High-Resolution Imager (HRIEUV) operating in 174 A being for the first time approximately at 0.5AU to the Sun, registered a large number of sudden heating events so-called campfires with rich morphology and smaller space-time characteristics than nanoflares. We found that campfires emit thermal energy in the picoflares range of $3.4 \times 10^{20} - 9.8 \times 10^{23}$ ergs per event. The relationship between the emission measure and the temperature of campfires can be fitted by the power law covering 1 - 2.7 MK temperature range similar to large X-Ray flares. Their frequency distribution can be fitted by power-law $f(E) \approx E^{2.82\pm0.11}$, but at higher than nanoflares frequencies and lower energy range. The additional previously unaccounted energy input of $\geq 3\sigma$ is 1.0075 percent of the total required power to sustain a quiet solar corona. The observed power law would have to continue to about 1.25×10^{18} ergs in order to fulfill the observed coronal heating requirement.

Invited Talk EP 5.3 Wed 11:30 ZEU/0160

Studying solar flares with the X-ray telescope STIX during the cruise and early science phase of Solar Orbiter — •Alexander Warmuth — Leibniz-Institut für Astrophysik Potsdam (AIP)

Of the six remote-sensing instruments aboard Solar Orbiter, the Spectrometer/Telescope for Imaging X-rays (STIX) is the one dedicated to the study of solar flares. It performs X-ray imaging spectroscopy in the hard X-ray regime, which provides key physical diagnostics on both the hot thermal plasma as well as on the accelerated energetic electrons. During its operation since launch in 2020, which now includes the first year of the nominal mission phase, STIX has detected over 10000 solar flares. The first scientific results based on these novel observations will be discussed. In particular, we will focus on studies that use STIX jointly with other observational assets, such as the other remote-sensing instruments on Solar Orbiter, various X-ray instruments on other spacecraft, and in-situ particle detectors.

EP 5.4 Wed 12:00 ZEU/0160

Joint LOFAR and STIX observations of flare-accelerated electrons in the solar corona — •Malte Bröse — Leibniz-Institut für Astrophysik Potsdam (AIP), Germany

A joint analysis approach is used to study flare signatures both in the low and higher corona. STIX, AIA and LOFAR data provide an extensive picture about different aspects of flare characteristics. Recent data by the STIX instrument complement the picture of accelerated electrons, which propagate along magnetic field lines towards the Sun. These observations are linked to the LOFAR data, which contain information about the elctrons propagating away from the Sun through the corona above the active region. Although, the active region and its thermal evolution (Differential Emission Measure (DEM) reconstruction of AIA data), flare accelerated electrons and their radio traces (LOFAR, STIX) are in principal all associated with the energy release during the flare process, they are often studied seperatly. Hence, the investigation of possible relations is part of this project. Solar magnetic fields as a binding element between low and high corona, accelerated electrons and heated flare loops are included in the analysis via a Potential Field Source Surface (PFSS) model.

EP 5.5 Wed 12:15 ZEU/0160

Exploring the inner heliosphere with combined LOFAR and Solar Orbiter / Parker Solar Probe observations — •Christian Vocks for the LOFAR Solar and Heliospheric KSP-Collaboration — Leibniz-Institut für Astrophysik Potsdam (AIP), Potsdam, Germany

The phenomena of the active Sun, like flares and coronal mass ejections (CMEs), have significant influence on Earth and our technical civilization. This is usually referred to as "Space Weather". Flares and CMEs accelerate electrons and ions to high energies. These particles are studied both remotely by ground- and space-based telescopes, and in situ by spacecraft. Energetic electrons emit radio waves as they move through the coronal plasma. This plasma emission is observed by radio telescopes, e.g. LOFAR. Since the frequency decreases with plasma density higher in the solar atmosphere, and radio waves below 10 MHz cannot pass Earth's ionosphere, spacecraft are needed to continue observations further into interplanetary space. They are also required for measuring energetic particles and observations of X-ray emission in the corona. Therefore, combining LOFAR and spacecraft data provides new insights into the physical processes in the region where the solar corona turns into the solar wind. Parker Solar Probe (PSP) and Solar Orbiter are two missions currently exploring the inner heliosphere. I'll present LOFAR observing campaigns during PSP and Solar Orbiter perihelia, that cover the Sun and it's surroundings by making use of LOFAR's capability of running multiple observing modes in parallel, and show how they connect the corona with the heliosphere.

EP 5.6 Wed 12:30 ZEU/0160

Quasi-discontinuous solar wind solutions — •Lukas Westrich — Ruhr-Universität Bochum, Institute for theoretical physics IV

In this talk the solar wind and its acceleration and heating will be examined. 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. First I will present the motivation and the physical background for this solutions. After a discussion of this new discontinuous concept for the solar wind, I will develop and discuss 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 will be done both stationary and dynamically. This kind of solutions can reproduce the analytically derived solutions without discontinuous jumps in the physical properties.

EP 6: Members' Assembly

Time: Wednesday 13:00–14:00 Location: ZEU/0160

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

EP 7: Sun and heliosphere II

Time: Wednesday 14:15–15:45 Location: ZEU/0160

Invited Talk EP 7.1 Wed 14:15 ZEU/0160

Advances in energetic particle physics with Solar Orbiter & Parker Solar Probe — •Robert F. Wimmer-Schweingruber[1], Javier Rodriguez-Pacheco[2], George C. Ho[3], Robert A. Allen[3], Raul Gomez-Herrero[2], and and the Solar Orbiter EPD Team[4] — [1]Institute of Experiemental and Applied Physics, Kiel University, Kiel, Germany — [2]Universidad de Alcalá, Space Research Group, 28805 Alcalá de Henares, Spain — [3]Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA — [4]all over the world

Parker Solar Probe (PSP) and Solar Orbiter are investigating the inner heliosphere and approaching the Sun closer than any previous mission ever has. The state-of-the-art energetic particle instruments aboard the two spacecraft - together with other instruments on multiple spacecraft - present us with a wealth of data that are helping us to understand how the Sun shapes and controls the heliosphere.

Being so close to the Sun allows to disentangle transport effects from the original signatures of particle acceleration at the Sun. The sophisticated remote-sensing instrumentation provides crucial information about the solar source regions.

We will present new results from PSP and Solar Orbiter and provide an update on their current status.

EP 7.2 Wed 14:45 ZEU/0160

Anisotropies of solar energetic electrons in the MeV range measured with SolO/EPD/HET — •Sebastian Fleth[1], Patrick Kühl[1], Alexander Kollhoff[1], Robert F. Wimmer-Schweingruber[1], Bernd Heber[1], Javier Rodríguez-Pacheco[2], and Nina Dresing[3] — [1]Institute of Experimental & applied Physics, Kiel University, 24118 Kiel, Germany — [2]Space Research Group/Universidad de Alcalá, Madrid, Spain — [3]Department of Physics and Astronomy, University of Turku, Turku, Finland

Solar Orbiter is an ESA-led mission of international collaboration with NASA to investigate how the Sun creates and controls the heliosphere, and why solar activity changes with time. One of its top-level science questions is how solar eruptions produce energetic particle radiation that fills the heliosphere. With its four viewing directions the High-Energy telescope (HET) provides critical information about the sources and transport of high-energy particles. This study analyses relativistic electron measurements obtained by HET in the energy range from 200 keV to above 10 MeV. The purpose of this study is to analyse anisotropies of relativistic solar energetic electrons utilizing the different viewing directions of HET. Time periods with enhanced fluxes of relativistic electrons, have been identified. A list of these time periods including additional observations such as maximum energy and flux as well as the first order anistropy will be presented. This is the first time since the Helios mission that anisotropies of high energy electrons have been measured.

Invited Talk EP 7.3 Wed 15:00 ZEU/0160

New Insights in Simulations of SEP Events with the PARADISE+ICARUS Model — •Edin Husidic[1,2], Nicolas Wijsen[1,3,4], Tinatin Baratashvili[1], Stefaan Poedts[1,5], and Rami Vainio[2] — [1]KU Leuven, Belgium — [2]University of Turku, Finland — [3]NASA, Goddard Space Flight Center, Greenbelt, USA — [4]University of Maryland, USA — [5]University of Maria Curie-Skłodowska, Lublin, Poland

The study of solar energetic particle (SEP) events plays a particularly important role in space weather research. While propagating through interplanetary space, fast coronal mass ejections (CMEs) generate shock waves that can efficiently accelerate ions and protons to energies of deka-MeV and beyond, posing a significant threat to astronauts and spacecraft. It is thus of major concern to develop numerical simulations that can realistically model the acceleration and transport of SEPs. We present simulations of SEP events in the inner heliosphere with the novel PARADISE+ICARUS model. The MPI-AMRVAC-based ICARUS code generates realistic background solar wind configurations from 0.1 au onward that serve as input for PARADISE (PArticle Radiation Asset Directed at Interplanetary Space Exploration). By solving the focused transport equation in a stochastic manner, PARADISE obtains intensities of SEP distributions. Using ICARUS's ability of adaptive mesh refinement (AMR) allows us to increase the spatial resolution at interplanetary shock waves and investigate how simulation results are affected by it. Our results are compared to previous ones obtained by the AMR-lacking PARADISE+EUHFORIA model.

EP 7.4 Wed 15:30 ZEU/0160

Nonlinear diffusive shock acceleration in a spherical geometry* — •Dominik Walter, Horst Fichtner, and Frederic Effenberger — Ruhr-Universität-Bochum Tp4, Bochum, Germany

Based on previous investigations in a Cartesian geometry, we now discuss the influence of a self-consistent diffusion coefficient on the transport of energetic particles in a spherical geometry. The formulation of the diffusion coefficient is motivated by taking into account the diffusing particles' influence on the scattering centers in the background medium. The resulting single transport equation is nonlinear due to a dependence of the diffusion coefficient on the gradient of the particle distribution. After trying to predict, based on insights from linear theory, the behaviour of the solutions of the nonlinear equation in a shock acceleration model in spherical geometry, numerical methods are applied to the equation to explore the time evolution of the solutions and to investigate the features of the steady-state shock spectra. The results are dicussed in the context of Cosmix Ray modulation in the heliosphere.

*Supported by DFG (SFB\,1491)

EP 8: Sun and heliosphere III

Time: Wednesday 16:00–17:15 Location: ZEU/0160

Invited Talk EP 8.1 Wed 16:00 ZEU/0160

Precision measurements of cosmic ray fluxes from AMS-02 with a daily time resolution — •Stefan Schael — I. Physikalisches Institut, RWTH Aachen, Sommerfeldstr. 14, D-52074 Aachen

The Alpha Magnetic Spectrometer, AMS-02, is a general-purpose high-energy particle physics detector. It was installed on the International Space Station in May 2011 to conduct a unique long duration mission of fundamental physics research in space. In 11 years AMS-02 has continuously collected data from more than 200 billion cosmic rays. The AMS-02 precision measurements have revealed new and distinct information that change our understanding of the production, acceleration and propagation of charged cosmic rays. In this presentation the recent measurements of the proton, helium, electron and positron fluxes with a daily time resolution will be summarized. These new precision measurements provide unique inputs to the understanding of cosmic rays in the heliosphere.

EP 8.2 Wed 16:30 ZEU/0160

Studies of energetic particle transport in synthetic turbulence with intermittency features — •Frederic Effenberger, Jeremiah Lübke, Horst Fichtner, and Rainer Grauer — Ruhr-Universität Bochum, Theoretische Physik

The transport of fast charged particles in turbulent magnetic fields is a key research topic in space- and astrophysics. In particular, regimes of superdiffusive or subdiffusive propagation and interactions with large and small-scale coherent features are important to study in more detail. A common approach to investigate turbulence-particle interactions is based on full-orbit calculations of test-particle trajectories in artificially generated turbulence. These turbulence models have the advantage, when compared to an MHD approach, that they can potentially cover a wider dynamical range of turbulence scales. However, almost all synthetic turbulence models to this date only include second-order Gaussian statistics and thus fail to include coherent structures and intermittent features. Our new model is based on a continuous wavelet transform of a log-normal cascade process, which results in realistic intermittent scaling properties. We investigate the particle transport properties by solving a large number of particle orbits in these synthetic turbulence realisations and specifically look for non-diffusive regimes and non-standard energy dependences resulting from the intermittency of the generated fields. The implications for solar energetic particle and cosmic ray transport are discussed.

EP 8.3 Wed 16:45 ZEU/0160

Comparison of spatial diffusion tensors using an axisymmetric model of heliospheric modulation of cosmic rays — •Dustin Lee Schröder, Horst Fichtner, and Jens Kleimann — Ruhr-Universität Bochum, Bochum, Deutschland

A 3D partial differential equation solver is used to solve the steady state Parker transport equation for an axisymmetric model of the heliosphere in order to study the influence of spatial diffusion tensors on cosmic ray modulation. The diffusion tensor can either be specified as an analytical function or be used as a value calculated with a turbulence model.

EP 8.4 Wed 17:00 ZEU/0160

The effect of kinetic turbulence on particle transport — •Felix Spanier — Institut für Theoretische Astrophysik, Universität Heidelberg

The transport of energetic charged particles depends on the underlying turbulence. Commonly non-dispersive waves and associated turbulence models (Kolmogorov or in some cases Goldreich-Sridhar) are used in modeling transport parameters. For frequencies close to and beyond the ion-gyrofrequency these assumptions are not applicable anymore.

We have used MHD as well as Particle-in-Cell simulations to study the difference between transport of particles in non-dispersive fluid and dispersive kinetic models. We will focus specifically on the transport of particles moving perpendicular to the magnetic field. The results are specifically interesting for the diffusion of electrons and positrons which resonate with waves with frequencies beyond the ion gyrofrequency.

EP 9: Poster

Time: Wednesday 17:30–19:00 Location: HSZ OG1

EP 9.1 Wed 17:30 HSZ OG1

PUNCH4NFDI - Synergies & Services for SMuK — •Michael Zacharias for the PUNCH4NFDI Consortium-Collaboration — LSW, Universität Heidelberg

PUNCH4NFDI (Particles, Universe, NuClei & Hadrons) is a consortium of the NFDI, and merges the SMuK community's efforts to store, manage and connect (big) data streams and their related metadata following the FAIR principles. Here, I will present the Synergies & Services that PUNCH is going to offer to the community at large - with a focus on Astrophysics. The main tool will be the Science Data Platform, where any connected data can be accessed and analyzed. The Marketplace will be a community forum to share and distribute data management tools and scripts. I will present examples for such tools, namely the ontology platform phyics.tools and an arxiv search tool for software products used in research.

EP 9.2 Wed 17:30 HSZ OG1

Extragalactic neutrino factories — •Sara Buson[1], Andrea Tramacere[2], Leonard Pfeiffer[1], Lenz Oswald[1], Gaetan De Fichet Clairfontaine[1], Alessandra Azzollini[1], Vardan Baghmanyan[1], Marco Ajello[3], and Eleonora Barbano[1] — [1]Lehrstuhl für Astronomie, Universität Würzburg, Emil-Fischer-Straße 31, 97074, Würzburg — [2]Department of Astronomy, University of Geneva, Ch. d'Ecogia 16, Versoix, 1290, Switzerland — [3]Department of Physics and Astronomy, Clemson University, Kinard Lab of Physics, Clemson, SC 29634-0978, USA

Identifying the astrophysical sources responsible for the high-energy cosmic neutrinos has been a longstanding challenge. In a previous study, we report evidence for a spatial correlation between blazers from the 5th Roma-BZCat catalog and neutrino data collected by the IceCube Observatory in the Southern celestial hemisphere. The probability that such correlation is found by chance is about one in a million (2 x 10-6). In this conference contribution, we present an extension of the analysis to a complementary IceCube dataset, and put the findings into the context of the previous results.

EP 9.3 Wed 17:30 HSZ OG1

BlaST: A machine-learning estimator for the synchrotron peak of blazars — Theo Glauch and •Tobias Kerscher — Technische Universität München, Physik-Department, James-Frank-Str. 1, Garching bei München, D-85748, Germany

Blazars, jetted Active Galaxy Nuclei (AGN) pointing towards us, occupy an important place in the field of high-energy astrophysics. Their classification depends heavily on the peak frequency of the synchrotron emission in the spectral energy disitribution (SED), yet this value is usually determined manually. In this contribution, we present a tool using machine learning to not only streamline this process, but also give a reliable uncertainty evaluation. By the very nature of this method, additional components of the SED stemming from the host galaxy or disk emission, possible sources of confusion, are accounted for.

EP 9.4 Wed 17:30 HSZ OG1

Analytic solutions for the hadronic time-dependent two-zone blazar model — •Vito Aberham and Felix Spanier — Institut für Theoretische Astrophysik (ITA), Albert-Ueberle-Str. 2, 69120 Heidelberg

Active galactic nuclei's (AGN) distinct variability is examined analytically by applying an evolving two-zone model to their jets. It is focused on hybrid jets containing both electrons and protons, since they allow for the additional emission of neutrinos. The dominant source of variability, jets of AGN are characterized by the cooling process mainly driving the emergence of the spectral energy distribution's high-energy peak. A scenario comprising blazars with proton synchrotron radiation as the predominant emission mechanism for high energies, while, as usual, electron synchrotron radiation drives the low energy emission, is chosen here. Dominant emission due to cascades is among cases considered in upcoming works. Incorporating both their acceleration and cooling in the respective zones, the particle distributions are calculated by solving two coupled partial differential equations while the effect of second-order Fermi acceleration is neglected. The associated photon density is obtained, which, combined with the proton distribution, eventually yields the emerging neutrino flux. Both the according light curves and neutrino fluxes in specific energy bands are ultimately inferred, enabling comparisons to observed blazars. Ultimately, a tool, which simulates a blazar's flare by exploiting the analytical results' dependence on the set of free model parameters, is presented to very quickly cross-check numerical simulations at low computational cost.

EP 9.5 Wed 17:30 HSZ OG1

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

It is hardly possible to resolve the geometry of astrophysical compact objects due to their small size. One possibility to indirectly learn about their structure are polarization measurements. Especially in the hard X-ray range polarization data is still partially missing. Therefore, the aim of the CubeSat mission ComPol is to improve the physical model of the black hole binary system Cygnus X-1 by measuring the polarization of its hard X-ray spectrum (20-200keV).

The detector system developed for the ComPol project is composed of a Silicon drift detector used as a scatterer and a $CeBr_3$ scintillator read out by a SiPM matrix. From the scintillation light distribution it is possible to determine the absorption position in the $CeBr_3$ which

is done to capture the full Compton kinematics. The next step is to perform an event-wise reconstruction from the measured energies and interaction points. The resulting distribution of the azimuthal scatter angles allows to directly infer the polarization of the initial radiation. The talk will give an overview of the scientific motivation, the underlying physics and the detector setup.
This research is supported by the Excellence Cluster ORIGINS which is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy - EXC-2094-390783311

EP 9.6 Wed 17:30 HSZ OG1

Das Universum als Energiesystem ermöglicht die Große Vereinheitlichte Theorie — •Günter von Quast — Winterweg 4; 76344 Eggenstein-Leopoldshafen

Die *Neue Physik* geht von einem Universum aus, das aus einem Energiefeld besteht. Die physikalischen Parameter dieses Energiefeldes sind die Planck-Einheiten und belegen ein Medium mit Planck-Druck und Planck-Dichte und der Planck-Energie sowie der Planck-Masse und der Planck-Ladung und vielen weiteren physikalischen Parametern und mathematischen Beziehungen. Alle Vorgänge in diesem Energiefeld sind energetische Vorgänge. Dazu gehören die Energetische Strahlung als Licht aller Frequenzen und auch das Wesen der Gravitation. Auch die Materie entsteht in diesem Energiefeld und ist nur ein vorübergehender Aggregatzustand der Raum-Energie und kann sich somit auch wieder zu der Raum-Energie auflösen. Die Fusionsstrahlung der sich abbauenden Sterne füllt den Raum aus. Somit ist die Hintergrundstrahlung die Plancksche Schwarzkörperstrahlung als energetischer Zustand des Raumes. Energie geht nicht verloren und Materie verschwindet nicht in den Schwarzen Löchern der Galaxien, was zu beachten ist. Die Zentren der Galaxien sind Strudelsysteme in dem Feld der Raum-Energie. Die Materie entsteht in den Zenten der Galaxien. Die Materie besteht aus den Strudelfeldern, den Quarks und diese bilden die Elementarteilchen und Atome aus. Die Materie besteht aus der Energie des Feldes der Raum-Energie. Dafür gibt es die *Neue Physik* als Energiefeld-Theorie. Die Standard- Theorien erklären nicht die Natur der Physik des Universums.

EP 9.7 Wed 17:30 HSZ OG1

Unveiling the dense molecular environments of evolved massive stars — •Michaela Kraus[1], María Laura Arias[2], Michalis Kourniotis[1], Andrea Torres[2], and Lydia S. Cidale[2] — [1]Astronomical Institute, Czech Academy of Sciences, Ondřejov, Czech Republic — [2]Instituto de Astrofísica de La Plata, CONICET, UNLP, La Plata, Argentina

The evolution of massive stars passes through states with intense mass-loss and eruptions, leading to the formation of dense and warm circumstellar environments, in which molecules and dust can form. Our research focuses on two specific such evolutionary stages: the B[e] supergiants and the yellow hypergiants, with the aim to reveal the structure and dynamics of their circumstellar matter. For this, we collected high-resolution near-infrared spectra for a sample of stars, using facilities at GEMINI Observatory. We discovered emission from hot CO gas in a few objects, based on which we derive the gas temperature, column density and kinematics within the line-forming regions. Interestingly, the yellow hypergiants and the B[e] supergiants with CO band emission share the same evolutionary tracks, and we discuss possible implications of this finding regarding potential evolutionary connections between these two phases.

EP 9.8 Wed 17:30 HSZ OG1

Evolution and radio emission of interacting plasma bunches in pulsar magnetospheres — •Jan Benáček[1], Patricio Muñoz[2,3], Jörg Büchner[3,2], and Axel Jessner[4] — [1]Intitute for Physics and Astronomy, University of Potsdam, Germany — [2]Max Planck Institute for Solar System Physics, Göttingen, Germany — [3]Center for Astronomy and Astrophysics, Technical University of Berlin, Germany — [4]Max Planck Institute for Radio Astronomy, Bonn, Germany

Pulsars are neutron star that emits coherent radio beams out of their magnetic poles. However, the origin of their radio emission is still under investigation. One of the proposed emission mechanisms exploits plasma bunches/clouds of electron-positron pairs created during spark events in gap regions. We utilized particle-in-cell simulations of relativistically hot bunches to investigate the bunch's nonlinear evolution and radiation by linear acceleration emission. We found that the main parameter influencing the bunch evolution is the initial drift velocity between electrons and positrons. For zero drift, the bunches can freely expand, and adjacent bunches may overlap in the phase space and form relativistic streaming instability. Otherwise, for non-zero drifts, the bunches are constrained from expansion and form strong oscillating electrostatic fields. Plasma particles may oscillate in these fields and emit radio waves. Furthermore, we found that the bunches constrained from expansion have similar observational characteristics as those observed for pulsars. Their spectrum contains a flat part for low frequencies and power-law profiles for higher frequencies.

EP 9.9 Wed 17:30 HSZ OG1

Quantitative spectroscopy of B-type supergiants — •David Wessmayer[1], Norbert Przybilla[1], and Keith Butler[2] — [1]Institut für Astro- und Teilchenphysik, Universität Innsbruck, Technikerstr. 25/8, 6020 Innsbruck, Austria — [2]LMU München, Universitätssternwarte, Scheinerstr. 1, 81679 München, Germany

B-type supergiants are a resourceful tool in adressing various astrophysical questions concerning stellar atmospheres, stellar and galactic evolution and the cosmic distance scale. To facilitate a comprehensive analysis of these objects we assess the applicability of a hybrid non-LTE approach, in which line-blanketed model atmospheres computed under the assumptions of local thermodynamic equilibrium (LTE) are combined with non-LTE line-formation calculations. High-resolution Echelle spectra – constituting an observational sample of 14 Galactic B-type supergiants with masses below about 30 $M_\odot$ – serve as the basis of this investigation. The results of the analysis, including atmospheric and fundamental stellar parameters, multi-species abundances and derived spectroscopic distances, are probed via multiple checks of consistency. Finally, we also test the employed methodology for analyses of intermediate-resolution spectra of extragalactic B-type supergiants.

EP 9.10 Wed 17:30 HSZ OG1

Characterization of B supergiant variability — •Suryani Guha[1,2], Michaela Kraus[1], and Julieta Arias Sanchez[1] — [1]Astronomical Institute, Czech Academy of Sciences, Ondrejov, Czech Republic — [2]Charles University, Prague, Czech Republic

B supergiants (BSGs) are famous for their spectroscopic variability that has been assigned to pulsations and related changes in their stellar wind properties. The pulsation modes of BSGs are strongly correlated to the stellar evolution phase. When a massive star has lost significant mass during its red-supergiant stage, it would return to the blue region in the Hertzsprung-Russell diagram and spend a part of the core-He burning stage as a BSG. In this particular phase it excites many pulsation modes including radial strange modes. The latter have been proposed to facilitate mass-loss. Our studies utilize data from the TESS (Transiting Exoplanet Survey Satellite) mission, which revealed that numerous BSGs display a rather irregular behaviour of their light curves, a likely indicator of radial strange mode pulsations. The optical spectra obtained from our observation campaign with the PEREK 2-m telescope are analyzed to search for variations in temperature and radius. Any detected variability can be directly linked with radial pulsations. Moreover changes in the strength and profile of the H-alpha line provide complementary information about wind variability. In this poster we will present highlights from a few interesting stars selected from our target list.

EP 9.11 Wed 17:30 HSZ OG1

Local HD flows at the Apex of an Astropause — •Kuljeet Singh Saddal[1,2] and Dieter H Nickeler[1] — [1]Astronomical Institute AV CR Ondrejov, Fricova 298, 25165 Ondrejov, Czech Republic — [2]Charles University, Faculty of Mathematics and Physics, V Holešovickách 2, 180 00 Praha 8, Czech Republic

Astrospheres are the interaction regions between the stellar wind and the ambient interstellar medium, which consists of various HD (or MHD) discontinuities. Astropause is a contact discontinuity that separates the two flows, and its structure is described by one of the separatrices of the fluid flow. In 2D, there must be at least one X-type null point (X-point) close to the apex. This analysis aims to study hydrodynamically the geometrical and topological structures of the streamlines in the vicinity of the X-point. As the flow close to the apex can be considered incompressible, one can make use of stream functions to describe such flows. The definition of streamlines, along with the equations of ideal HD, gives a single, (non-)linear elliptic partial differential equation, known as the Grad-Shafranov equation (GSE). This equation is analysed by approximating the stream function close to the null point as a series of polynomials to various orders, and assuming specific forms for the pressure function. Depending on the choice of the pressure function and the order at which the polynomial is truncated, either the original null point can become an X-point of higher order, or more null points can appear in its vicinity. Moreover, an isotropic pressure might not exist for every choice of stream functions, and hence adding an extra anisotropic term becomes important.

EP 9.12 Wed 17:30 HSZ OG1

The Liquid Metallic Hydrogen Model of the Sun — •Alexander Unzicker — Pestalozzi-Gymnasium München

Though the standard solar model based on a gaseous plasma dominates the scientific discourse, a considerable amount of experimental evidence may also be interpreted assuming a real, liquid surface of the sun, as proposed by Robitaille (Progress in physics vol.3, 2011). Data from new missions must be open to such a different paradigm.

EP 9.13 Wed 17:30 HSZ OG1

Extending SOHO-EPHINs energy range for Helium nuclei — •Malte Hörlöck, Bernd Heber, Patrick Kühl, and Stefan Jensen — Christian-Albrechts-Universität zu Kiel

Galactic cosmic rays are composed mainly of protons, helium nuclei and electrons. The flux of these particles is modulated due to the heliospheric magnetic field that shields lower energy particles from the heliosphere. Hence, the flux depends on the solar activity. During phases of low and high solar activity, a maximum and minimum in the flux is observed, respectively. The SOlar and Heliospheric Observatory (SOHO) was launched in 1995. The Electron Proton Helium INstrument (EPHIN) onboard SOHO is a particle telescope, consisting of a stack of 6 silicon semiconductor detectors surrounded by an anticoincidence detector. The instrument stops protons and helium nuclei up to energies of 51 MeV/nucleon. At higher energies, these particles penetrate the telescope. As shown previously EPHIN provides sufficient information to obtain the flux of protons up to an energy of about a GeV. Here we investigate the instrument capabilities to obtain helium fluxes for energies above 51 MeV/nucleon using the dE/dx-dE/dx-method. However, the task is hampered by the fact that two detectors became noisy in 1998 and 2017, respectively. Thus, extensive modeling utilizing the GEANT4 package is needed in order to derive helium fluxes up to about 100 MeV/nucleon.

EP 9.14 Wed 17:30 HSZ OG1

Flux-rope nonequilibrium in the slow-rise phase of solar eruptions — •Bernhard Kliem — Universität Potsdam, Institut für Physik und Astronomie

Solar eruptions are nearly always preceded by a slow-rise phase that comprises an ascent of the eventually erupting filament (or prominence) in the corona and a slow increase of the soft X-ray flux. This is a distinct phase characterized by intermediate velocities of typically several 10 $\mathrm{km\,s^{-1}}$ (in active regions up to ~ 100 $\mathrm{km\,s^{-1}}$), 1–2 orders of magnitude faster than the quasi-static evolution during energy storage, which scales with the driving photospheric velocities, and 1.5–3 orders of magnitude below the coronal Alfvén velocity, V_A, which is the scaling parameter of eruption speeds and their upper limit. Proposed mechanisms of this phase range from distributed small-scale ("tethercutting") reconnection events in sheared field to a nonequilibrium and even ideal magnetohydrodynamic instability of a flux rope. I present simulations of flux cancellation that show the formation of a flux rope, a quasi-static evolution with a rise speed similar to the imposed photospheric driver, then a slightly faster rise, gradually accelerating up to $\approx 10^{-2}\ V_\mathrm{A}$, and eventually the eruption of the rope by onset of the torus instability. The flux rope is shown to be in a nonequilibrium state during the slow rise.

EP 9.15 Wed 17:30 HSZ OG1

Neutral Current Sheet Displacement in Reaction to the Radial Interplanetary Magnetic Field at Mercury: Statistical Results from MESSENGER Data. — •Daniel Heyner[1], Kristin Pump[1], David Hercik[2], Willi Exner[3], Yasuhito Narita[4], Ferdinand Plaschke[1], Daniel Schmid[4], Jim Slavin[5], and Martin Volwerk[4] — [1]TU Braunschweig, Braunschweig, Germany — [2]Institute of Atmospheric Physics, Prague, Czech Republic — [3]ESA, Noordwijk, Netherlands — [4]IWF, Graz, Austria — [5]University of Michigan, Ann Arbor, USA

Mercury possesses a small magnetosphere and on the nightside, a neutral current sheet elongates the magnetic field lines. From hybrid simulations it is known that this current sheet reacts to changes in the interplanetary magnetic field (IMF). The radial IMF at Mercury facilitates magnetopause reconnection in high latitudes which decreases the magnetic pressure in one of the magnetospheric lobes depending on the radial IMF polarity. This produces a north-south shift of the neutral sheet. We present statistical results from in-situ MESSENGER magnetic field data analysis on the IMF direction as well as the neutral sheet displacement. MESSENGER was a single probe in orbit around Mercury and it was blind to the IMF after having entered the bow shock. We need to estimate the current IMF radial polarity for the time with the probe inside the magnetosphere. We evaluate different interpolation methods with an adapted bootstrap analysis method on solar wind data at Mercury. The analysis results on the neutral sheet displacement is compared to hybrid simulations done in the past.

EP 9.16 Wed 17:30 HSZ OG1

Concepts for the measurement of permittivity profiles in extraterrestrial cryospheres to improve subsurface radar images — •Gianluca Boccarella, Fabian Becker, Alexander Kyriacou, and Klaus Helbing — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal

Icy moons like Europa and Enceladus may contain microbial life in their subsurface oceans. Surface and subsurface imaging with radar is a promising technique to investigate their interior and identify a target for a subsurface exploration with melting probes. The main uncertainty of radar images is the unknown permittivity (ϵ) of the medium through which the electromagnetic waves travel. Therefore, we developed two methods to measure the ϵ from the medium of interest. Both methods were successfully tested on alpine glaciers as comparable terrestrial environments and the results will be presented. The initiatives involved are the DLR-funded projects EnEx and TRIPLE.

The first method is a cross-borehole FMCW radar: by sending signals between two antennas, it is possible to use the time of flight for permittivity reconstruction. An inversion of radio propagation simulations is used to reconstruct the permittivity profile from time of flight measurements at different depths. The second approach is to use a permittivity sensor, which is placed in a melting probe with an integrated radar system. This sensor can measure in the near field of the melting probe and immediately corrects the radar image. It represents a part of the forefield reconnaissance system being developed for melting probes.

EP 9.17 Wed 17:30 HSZ OG1

About the Radiative Transfer (RT) and inversion codes used in the characterization of planetary atmospheres — Rengel Miriam[1] and •Adamczewski Jakob[1,2] — [1]Max-Planck-Institut für Sonnensystemforschung — [2]Georg-August-Universität Göttingen

This contribution represents a tour on Radiative Transfer (RT) and inversion codes used in the planetary and exoplanetary communities from the perspective of a user. Such codes predict and interpret spectra of planetary atmospheres (hydrostatic equilibrium atmospheres and expanding comas) and infer atmospheric properties like temperature and abundance profiles (forward modelling and inversion algorithm, respectively). The retrieved atmospheric properties can offer crucial information into the atmospheric physico-chemical processes of planets and their formation mechanisms.

Here we present a mini overview of some existing forward and inversion codes used in the planetary science and some examples of applications. Space and ground-based telescope facilities used in the field (feasibility studies, observational planning, etc.) depend on the quality and extent of these codes.

EP 9.18 Wed 17:30 HSZ OG1

Retrieval of planetary albedo and cloud's properties of Earth with spectropolarimetry — •Giulia Roccetti[1,2], Michael Sterzik[1], Claudia Emde[2], and Mihail Manev[2] — [1]European Southern Observatory, Garching bei München, Germany — [2]Ludwig-Maximilians-Universität München, München, Germany

To prepare the search for life outside our Solar System, we must characterise Earth as an exoplanet. In this work we present a novel approach to retrieve the planetary albedo and cloud's properties (mean water cloud optical depth and cloud cover) of Earth with spectropolarimetry. Incoming (unpolarised) stellar light is polarised by molecular or particle scattering in the Earth's atmosphere or from reflection at the planetary surface. The polarization phase curve, and its spectral dependencies, allow to constrain many atmospheric and surface properties of the planet.

We show that planetary albedo can be retrieved analyzing the slope of the polarization spectra, while for the could's properties we use a two-tier approach: we first determine the mean optical depth using the cloudbow feature at small phase angles (for a wavelength in the near-infrared range), and then we estimate the cloud cover using the maximum of the phase curve (for a wavelength in the B band).

The results are compared with Earthshine observations, i.e. sunlight scattered by the dayside Earth and reflected back to Earth from the darker portion of the visible moon, which allows to observe the Earth as an exoplanet at different phase angles, as the relative Sun-Earth-Moon viewing geometry changes.

EP 9.19 Wed 17:30 HSZ OG1

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. 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 on a ≈3000 km wide swath with a ≈10×10 km^2 pixel resolution. From the UV emissions 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 particularly targeted for use in climate models that include the upper atmosphere, such as WACCM-X or EDITh. We also present a comparison to current implementations for ionization rates used in these two models.

EP 9.20 Wed 17:30 HSZ OG1

Modeling of the count and dose rate of the DOSimetry TELescope (DOSTEL) aboard the International Space Station — Hanna Giese, Sönke Burmeister, •Bernd Heber, Konstantin Herbst, and Lisa Romaneehsen — Christian-Albrechts-Universität Kiel

The DOSimetry Telescope (DOSTEL) measures the radiation environment within the Columbus module of the International Space Station (ISS) by utilizing two semiconductor detectors. The Earth is continuously exposed to galactic cosmic rays and occasionally by Solar Energetic Particles. The magnetized solar wind in the heliosphere and the Earth's magnetic field alters the flux of these particles. In addition these particles need to propagate through the Earth magnetosphere leading to maximum and minimum fluxes at polar and equatorial latitudes. This dependency can be described by the Dorman function. In combination with the primary spectra of ions approximated by the force field solution, the Dorman function is ideally suited to describe the response of the instrument within the ISS. Thus it is sufficient to determine the response function (yield) for a few selected periods. In order to validate the yield function we predict the measurements for other periods including Forbush Decreases and compare to the actual observations.

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

EP 10: Astrophysics: Cosmic Rays and Galaxies I

Time: Thursday 11:00–13:00 Location: ZEU/0160

Invited Talk EP 10.1 Thu 11:00 ZEU/0160

Arne-Richter Lecture: From nonthermal plasmaastrophysics to modeling of pandemic outbreaks — •Reinhard Schlickeiser — Institut für Theoretische Physik, Lehrstuhl IV: Weltraum- und Astrophysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität zu Kiel, Leibnizstr. 15, D-24118 Kiel, Germany

During the last 45 years of my career I almost exclusively did research on topics of nonthermal astrophysics including gamma-ray astronomy, radio astronomy, cosmic ray transport and acceleration in partially turbulent electromagnetic fields, astroparticle physics, kinetic theory of fluctuations in collision-poor plasmas and cosmological magnetogenesis. I had the privilege to meet and interact with a number of splendid and marvelous scientists including Arne Richter. In the talk I will cover important milestones of my career and summarize my positive experiences with fellow scientists.

EP 10.2 Thu 11:45 ZEU/0160

Modelling magnetic turbulence with log-normal intermittency by continuous cascades* — •Jeremiah Lübke[1], Frederic Effenberger[2], Horst Fichtner[2], and Rainer Grauer[1] — [1]Institute for Theoretical Physics I, Ruhr-University Bochum, Universitätsstr. 150, 44801 Bochum — [2]Institute for Theoretical Physics IV, Ruhr-University Bochum, Universitätsstr. 150, 44801 Bochum

The transport of cosmic rays in turbulent magnetic fields is commonly investigated by solving the Newton-Lorentz equation of test particles in synthetic turbulence fields. These fields are typically generated from superpositions of Fourier modes with prescribed power spectrum and uncorrelated random phases, bringing the advantage of covering a wide range of turbulence scales at managable computational effort. However, almost all of these models to date only account for second-order Gaussian statistics and thus fail to include intermittent features. Recent observations of the solar wind suggest that astrophysical magnetic fields are strongly non-Gaussian, and the question of how such higher-order statistics impact cosmic ray transport has only received limited attention. To address this, we present an algorithm for generating synthetic turbulence based on Kolmogorov's log-normal model of intermittency. It generates a divergence-free magnetic field by computing the curl of a vector potential, which in turn is obtained from an inverse wavelet transform of a continuous log-normal cascade process. We investigate the statistics of the generated fields, show that anomalous scaling properties are accurately reproduced and discuss implications on cosmic ray transport. *Supported by DFG (SFB 1491)

EP 10.3 Thu 12:00 ZEU/0160

From test particle simulations to cosmic-ray transport — Marco Kuhlen, •Vo Hong Minh Phan, and Philipp Mertsch — TTK, RWTH Aachen University, Aachen, Germany

The transport of high-energy particles in the presence of small-scale, turbulent magnetic fields is a long-standing issue in astrophysics. Analytical theories disagree with numerical simulations at rigidities where the particles' gyroradii are slightly smaller than the correlation length of turbulence. At the same time, extending the numerical simulations to lower rigidities has proven computationally prohibitive. In this talk, we will discuss a solution to the problem of perpendicular transport in isotropic turbulence at both, high and low rigidities. Our study has important implications for the transport of Galactic cosmic rays, acceleration at perpendicular shocks and for high-energy particles in the heliosphere.

EP 10.4 Thu 12:15 ZEU/0160

Particle acceleration capability of a black hole at the Galactic centre — •Arman Tursunov — Institute of Physics, Silesian University in Opava, Czech Republic — Max Planck Institute for Radio Astronomy, Bonn, Germany

A compact supermassive source Sagittarius A* located at the centre of our Galaxy has been observed at different wavelengths across the electromagnetic spectrum. It is the closest and largest in projection supermassive black hole candidate. At the same time, its particle acceleration capability related to the cosmic ray and neutrino messengers were not yet experimentally probed despite indirect indications of the existence of a PeVatron at the Galactic centre. In this talk, I will present a novel scenario of particle acceleration at the Galactic centre involving electromagnetic extraction of rotational energy from the central black hole. I will show that the maximum energy of accelerated protons may reach a few PeV at the source, contributing thus to the knee of the observed cosmic ray spectrum.

EP 10.5 Thu 12:30 ZEU/0160

Multi-wavelength modelling of FR0 galaxies — •Therese Paulsen[1] and Foteini Oikonomou[2] — [1]Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal, Germany — [2]Norwegian University of Science and Technology, Høgskoleringen 5, NO-7491 Trondheim, Norway

In the last decade, high-sensitivity radio and optical surveys have unveiled a new class of radio galaxies, called the Fanaroff-Riley type 0 (FR0). Due to their abundance in the local universe, this source class is of particular interest in the context of multi-messenger analyses as a possible neutrino emitter. The properties of FR0s at γ-ray energies are still largely unexplored due to the lack of observational data. However, observations have been made for the galaxies LEDA 55267, LEDA 57137, and LEDA 58287.

The multi-wavelength emission of these galaxies was modeled to determine the physical conditions under which the observed radiation is generated. The synchrotron, synchrotron self-Compton and the external Compton processes were considered. As a first result, we find that all the sources are consistent with being powered by the synchrotron self-Compton mechanism.

EP 10.6 Thu 12:45 ZEU/0160

Bayesian Inference of the 3D Galactic HI-Gas Density — •Laurin Söding, Philipp Mertsch, and Vo Hong Minh Phan — Institute for Theoretical Particle Physics and Cosmology, RWTH Aachen University, Aachen, Germany

While other galaxies can be observed with various techniques in great detail and precision, the structure of our own galaxy is mostly obscured from view due to our vantage point. Creating a 3D map of e.g. HI gas density or magnetic fields is therefore a challenging task. We have used the 21-cm emission line from atomic hydrogen - together with a velocity model - to reconstrcut a 3D-map of the galactic distribution of HI gas using new Bayesian inference techniques. While the first results look very promising, we have characterised systematic uncertainties of the method due to, e.g. the choice of velocity model. In the future, we will strive to determine velocity fields and gas densities in a common inference machinery to obtain the best maps of the Galaxy yet.

EP 11: Near-Earth Space I

Time: Thursday 14:00–15:30 Location: ZEU/0160

Invited Talk EP 11.1 Thu 14:00 ZEU/0160

Energetic Particle Precipitation reflected in the Global Secondary Ozone Distribution — •Jia Jia[1,2], Lisa E. Murberg[1,3], Tiril Løvset[1], Yvan J. Orsolini[1,3], Patrick J. Espy[1,2], Jude Salinas[4,5], Jae N. Lee[4,5], Dong Wu[4], and Jiarong Zhang[6] — [1]Norwegian University of Science and Technology (NTNU), Trondheim, Norway — [2]Birkeland Centre for Space Science (BCSS), Norway — [3]NILU - Norwegian Institute for Air Research, Kjeller, Norway — [4]NASA Goddard Space Flight Center, Greenbelt, Maryland, USA — [5]University of Maryland, Baltimore County, Maryland, USA — [6]Coastal Carolina University, Conway, South Carolina, USA

The secondary ozone layer is a global peak in ozone abundance in the upper mesosphere-lower thermosphere (UMLT) around 90-95 km. The effect of energetic particle precipitation (EPP) from geomagnetic processes on this UMLT ozone has not been well studied. In this research we investigated how the secondary ozone response to EPP from the Microwave Limb Sounder (MLS) and the Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) instrument on the Aura and TIMED satellites, respectively. In addition, the Whole Atmosphere Community Climate Model with thermosphere and ionosphere extension and specified dynamics (SD-WACCM-X) was used to characterize the residual circulation during EPP events. By comparing ozone and circulation changes under High- and low-Ap conditions, we report regions of secondary ozone enhancement or deficit across low, mid and high latitudes as a result of circulation and transport changes induced by EPP.

EP 11.2 Thu 14:30 ZEU/0160

Comparison of D-region ion-chemistry in ExoTIC and EMAC with MIPAS observations — •Monali Borthakur[1], Miriam Sinnhuber[1], Thomas von Clarmann[1], Gabriele Stiller[1], and Bernd Funke[2] — [1]Karlsruhe Institute of Technology, Karlsruhe, Germany — [2]Instituto de Astrofísica de Andalucía, CSIC, Granada, Spain

Energetic particle precipitation (EPP) and ion chemistry affect the neutral composition of the polar middle atmosphere. For example, production of odd nitrogen and odd hydrogen during strong events like solar proton events can decrease ozone. However, the standard ion chemistry parameterisation used in atmospheric models neglects the effects on some important species. Studies have also shown that the increase of some species measured during solar proton events (SPEs) cannot be reproduced using the standard parameterisation of HOx and NOx production, while models considering D-region ion chemistry in detail agree better with the observations. Here we present results with D-region ion-chemistry in a 1D model ExoTIC and 3D model EMAC, which includes a set of lower ionosphere (D-region) chemistry: 413 reactions of 46 positive ions and 28 negative ions. Using AISSTORM ionisation rates, ExoTIC and EMAC simulations in the Northern polar region are compared with MIPAS satellite observations for the Halloween SPE of 2003. A focus is on the analysis of the chemical composition changes of different species due to the chlorine ion-chemistry in EMAC.

EP 11.3 Thu 14:45 ZEU/0160

Ring current electron precipitation during multiple geomagnetic storm events: the mechanism and the effect on the atmosphere — •Alina Grishina[1,2], Yuri Shprits[1,2,3], Miriam Sinnhuber[4], Michael Wutzig[1], Hayley Allison[1], Dedong Wang[1], Alexander Drozdov[3], and Matyas Szabo-Roberts[1] — [1]GFZ German Research Centre for Geosciences, Potsdam, Germany — [2]University of Potsdam, Potsdam, Germany — [3]University of California, Los Angeles, Los Angeles, CA, USA — [4]Karlsruhe Institute of Technology, Karlsruhe, Germany

The particle flux in the near-Earth environment can increase by orders of magnitude during geomagnetically active periods, which leads to intensification of particle precipitation into Earth's atmosphere and can further affect atmospheric chemistry and temperature. In this research, we concentrate on ring current electrons and investigate precipitation mechanisms using a numerical model based on the Fokker-Planck equation.

We investigate a time period that covers 4 corotating interaction region and 2 coronal mass ejection storms. Our results are validated against observations from the POES satellite mission, low Earth orbiting meteorological satellites, and Van Allen Probes. Maps of precipitating modeled fluxes for different energies allow us to understand in which regions on Earth precipitation is the most intensive. The output of the model is further used for calculation of ionization rates at different altitudes, allowing it to estimate effects of geomagnetically active periods on chemical and physical variability near the polar areas.

EP 11.4 Thu 15:00 ZEU/0160

A new approach to constrain space weather effects on the Earth's atmosphere — •Florian Haenel[1], Miriam Sinnhuber[1], Alina Grishina[2], and Yuri Shprits[2] — [1]Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Germany — [2]Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Potsdam, Germany

We investigate the impact of space weather on the Earth's middle atmosphere and its climate system using state of the art numerical models of the magnetosphere and atmosphere. In particular, we study the impact of electrons with medium-range energy, mostly from the Earth's radiation belts, lost into the atmosphere during geomagnetic storms. Previous studies, using ionization rates, based on electron fluxes measured by satellites show an underestimation of produced NOx ($NO+NO_2$) by comparison with satellite observations and exhibit a large uncertainty. NOx produced by electron precipitation in the mesosphere and lower thermosphere is the starting point of the so-called "indirect effect" altering stratospheric temperatures and winds, which even might impact surface climate. As consequence, this effect is consistently being underestimated in chemistry-climate models. We use a new approach to shed light on these uncertainties. We use precipitating electron fluxes simulated by the magnetospheric model VERB-4D, which will serve as an input for chemistry-climate simulations by the atmospheric model EMAC. Here, we will apply this combination of models in a case study of a geomagnetic active period in March/April 2010 and compare with previous data sets.

EP 11.5 Thu 15:15 ZEU/0160

Good timing — •David Wenzel — Deutsches Zentrum für Luft- und Raumfahrt, Institut für Solar-Terrestrische Physik, Neustrelitz

Several quantities observable on Earth follow day or year trends due to a significant impact of Sun light. The DLR Neustrelitz is for instance monitoring radio signals for reconstructing ionospheric properties in order to gain a deeper insight into the general coupling processes as well as developing warning systems for protecting technological systems from harm or malfunctioning by sudden disturbances like solar flares. The GIFDS (Global Ionospheric Flare Detection System) network of VLF receivers aims at issuing immediate alerts when possibly harmful flare events occur. The continously available VLF signals are heavily influenced by these. However, the measurements also experience a pronounced daytime variation, which has to be taken into account in designing warning algorithms. On the other side, the long-term observations moreover unveil annual characteristics. There is a sharp decrease of signal amplitudes during fall that is not symmetric to the increase in spring. This "October effect" is investigated in the project AMELIE. Grasping the year trends here will improve our view on the physics behind. Giving measurements an analytic representation is of interest for many reasons, but can turn out to be complicated. We will demonstrate that by adjusting the time scale in certain natural manner, modelling becomes easier with respect to appropriate ansatz functions and more accessible to relevant properties.

EP 12: Near-Earth Space II

Time: Thursday 15:45–17:15 Location: ZEU/0160

Invited Talk EP 12.1 Thu 15:45 ZEU/0160

Ultra-relativistic Electrons in the Earth's Van Allen Radiation Belts — •Yuri Y. Shprits[1,2,3], Hayley Allison[1], Nikita Aseev[1], Dedong Wang[1], and Alexander Drozdov[3] — [1]Department of Geophysics, German Research Center for Geociences, GFZ, Potsdam, Germany — [2]Institute of Physics and Astronomy, University of Potsdam, Germany — [3]Department of Earth, Planetary, and Space Sciences, UCLA

New measurements from the NASAs Van Allen Probes demonstrate that the Earth radiation belts cannot be considered as a bulk population above approximately electron rest mass, but ultra-relativistic electrons form a new population that shows a very different morphology and behavior. We show that acceleration to multi-MeV occurs locally due to energy diffusion by whistler mode waves. Local heating appears to be able to transport electrons in energy space from 100s of keV all the way to ultra-relativistic energies. Acceleration to such high energies occurs only for the conditions when cold plasma in the trough region shows extreme depletions. The difference between the loss mechanisms at MeV and multi-MeV energies is due to EMIC waves that can very efficiently scatter ultra-relativistic electrons but leave MeV electrons unaffected. We also present how the new understanding can be used to produce the most accurate data-assimilative forecast. Under the recently funded EU Horizon 2020 Project Prediction of Adverse effects of Geomagnetic storms and Energetic Radiation (PAGER), we will study how ensemble forecasting from the Sun can produce long-term probabilistic forecasts of the radiation environment.

EP 12.2 Thu 16:15 ZEU/0160

Magnetospheric formation processes of the diffuse aurora: Sensitivity of wave-induced electron scattering to the hot electron distribution — •Katja Stoll[1,2], Leonie Pick[1], Dedong Wang[3], and Yuri Shprits[2,3,4] — [1]DLR Institute for Solar-Terrestrial Physics, Neustrelitz, Germany — [2]University of Potsdam, Potsdam, Germany — [3]GFZ Potsdam, Potsdam, Germany — [4]University of California, Los Angeles, CA, USA

Resonant wave-particle interactions in the Earth's magnetosphere can lead to the scattering of plasma sheet electrons which in turn cause the optical phenomenon of diffuse aurora. Specifically, electrostatic electron cyclotron harmonic (ECH) waves can effectively precipitate hundreds of eV to tens of keV electrons into the upper atmosphere. This process can generally be treated as a diffusion problem, requiring the numerical calculation of bounce-averaged quasi-linear diffusion coefficients.

ECH waves are thought to be generated by the loss cone instability of the ambient hot electron distribution. Therefore, the determination of ECH wave-induced scattering rates requires information about the properties of the hot plasma sheet electrons responsible for the wave excitation. We report our progress on analysing the sensitivity of ECH wave-induced electron scattering effects to the temperature of the hot electron components, which has an influence on the growth rate of the waves.

EP 12.3 Thu 16:30 ZEU/0160

Measurements of cosmic rays by a mini neutron monitor aboard the German research vessel Polarstern. — •Bernd Heber[1], Sönke Burmeister[1], Hanna Giese[1], Konstantin Herbst[1], Lisa Romaneehsen[1], Carolin Schwerdt[2], Dutoit Strauss[3], and Michael Walter[2] — [1]Christian-Albrechts-Universität Kiel, D — [2]Deutsches Elektronen-Synchrotron DESY in Zeuthen, D — [3]Center for Space Research, NWU Potchefstroom, SA

Neutron monitors are ground-based devices that measure the secondary particle population, i.e., neutrons produced by, e.g., galactic cosmic rays (GCRs). Due to their functionality, they are integral counters whose flux is proportional to the variation of the input spectrum. However, the measured flux also depends on the geomagnetic position and the pressure at the monitor's location. To better understand the NM response regular monitoring of the GCR intensity as a function of latitude is needed. Therefore a portable NM was installed 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. Since the installation aboard the vessel, 12 latitude scans were performed, allowing us to compute the so-called yield function by experimental means presented in this contribution.

The Kiel team received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 870405. The team would like to thank the crew of the Polarstern and the AWI for supporting our research campaign.

EP 12.4 Thu 16:45 ZEU/0160

Yield function of the DOSimetry TELescope (DOSTEL) count and dose rates aboard an aircraft — •Lisa Romaneehsen, Hanna Giese, Bernd Heber, Konstantin Herbst, and Sönke Burmeister — Christian-Albrechts-Universität Kiel

The Earth is continuously exposed to galactic cosmic rays. The magnetized solar wind in the heliosphere and the Earth's magnetic field alters the flux of these particles. If cosmic rays hit the atmosphere, they can form secondary particles. The total flux measured within the atmosphere depends on the atmospheric density above the observer. Therefore, the ability of a particle to approach an aircraft depends on its energy, the altitude, and the position of the plane. The cutoff rigidity describes the latter.

The radiation detector of the detector system NAVIDOS (NAVIgation DOSimetry) is the DOSimetry Telescope (DOSTEL), measuring the count and dose rates in two semiconductor detectors. From 2008 to 2011, two instruments were installed in two aircraft. First, we corrected the data for pressure variation by normalizing them to one flight level and determined their dependence on the cutoff rigidity by fitting a Dorman function to the observation. The latter was used to compute the yield function, which describes the ratio of incoming primary cosmic rays, approximated by a force field solution, to the measured count and dose rate for a particular instrument.

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

EP 12.5 Thu 17:00 ZEU/0160

Development of a plasmapause model derived from Van-Allen-Probe data and IMAGE RPI data via automatic detection — •Daniela Banyś[1], Joachim Feltens[1,2], Norbert

Jakowski[1], Mainul Hoque[1], Rene Zandbergen[3], and Werner Enderle[4] — [1]Institute for Solar-Terrestrial Physics, DLR, Germany — [2]Telespazio-VEGA Deutschland GmbH c/o European Space Operations Centre, Germany — [3]European Space Operations Centre, Germany - retired — [4]European Space Operations Centre, Germany

The outer boundary of the plasmasphere, the plasmapause, is characterised by a sharp electron density gradient which changes under varying space weather conditions. With NEPPM (Neustrelitz ESOC Plasmapause Model), we introduce a new model of the plasmapause location Lpp based on electron density measurements made by the Van Allen probes from 2012 to 2016 and the IMAGE satellite from 2000 to 2005 that were automatically processed, yielding an improved performance for plasmapause detection. Applying a dipole based transformation of measurements, NEPPM is described by a simple elliptical approach in the equatorial plane determined by the semi-major axis, the eccentricity, and the orientation angle. The Lpp varies as a function of Dst index and magnetic local time (MLT), resulting in a tighter fit compared to the GCPM (Global Core Plasma Model). The distinctive bulge in the evening hours follows the level of solar activity. By extending the ellipse fitting from the equatorial plane to a 3D approach, the NEPPM also allows non-dipole B vectors, providing 3D positions on the plasmapause torus for given latitude, longitude, epoch and Dst.

EP 13: Astrophysics: Galaxies II

Time: Thursday 17:30–19:00 Location: ZEU/0160

Invited Talk EP 13.1 Thu 17:30 ZEU/0160

Time-dependent data analysis of a blazar flare — •Maximilian Albrecht and Felix Spanier — Universität Heidelberg - ITA

Active Galactic Nuclei (AGN) have been discussed as possible accelerators of ultra high-energy cosmic rays for quite some time. While direct observations of cosmic ray sources are still difficult, the emission of neutrinos could be observed directly. Various AGN emission models link the photon, cosmic ray and neutrino emission. Understanding and modeling the emission can help identifying AGN as cosmic accelerators. The available observational data does not yet allow for unique models, but considering also the time domain may aid in understanding the underlying emission mechanisms.

In this talk results of modeling the eruption of the blazar TXS 0506+056 in 2017 are discussed. This blazar was identified as the source of the high-energy muon neutrino IceCube-1709222A detected by the IceCube telescope. From a subsequent multimessenger-campaign a longer time series is available. Using the time-dependent, self-consistent, lepto-hadronic UNICORN-0D the observational data was simulated. We will discuss the possibilities of using time-dependent models to unveil the emission mechanisms and subsequently the associated spectrum of ultra-high energy cosmic rays.

EP 13.2 Thu 18:00 ZEU/0160

ExHaLe-jet: Modeling blazar jets with an extended hadro-leptonic radiation code — •Michael Zacharias — LSW, Universität Heidelberg

Blazars emit across all electromagnetic wavelengths. While the so-called one-zone model has described well both quiescent and flaring states, it cannot explain the radio emission and fails in more complex data sets, such as AP Librae. In order to self-consistently describe the entire electromagnetic spectrum emitted by the jet, extended radiation 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 newly developed hadro-leptonic extended-jet code: ExHaLe-jet. 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 induce injection of additional pairs through pion and Bethe-Heitler pair production, which can explain a dominant leptonic radiation signal while still producing neutrinos. In this talk, we discuss the differences between leptonic and hadronic dominated SED solutions, the SED shapes, evolution along the jet flow, and jet powers. We also highlight the important role of external photon fields, such as the accretion disk and the BLR.

EP 13.3 Thu 18:15 ZEU/0160

Improved numerical scheme for solving shock acceleration in jets using stochastic differential equations — •Patrick Günther, Sarah Wagner, and Karl Mannheim — Institute for Theoretical Physics and Astrophysics, University of Würzburg

Supersonic jets ejected from active galactiv nuclei show in situ acceleration of charged particles to ultrarelativistic energies far away from the central black hole. Diffusive shock acceleration and momentum diffusion, also known as 1st and 2nd order Fermi acceleration, are mechanisms that can explain the observed particle spectra. In the test-particle and diffusion approximation regime, the governing transport equations are Fokker-Planck equations equivalent to stochastic differential equations which can be solved numerically in a fast way. Advantages and disadvantages of this Monte-Carlo sampling method are discussed. The accuracy of the results depends on the choice of the numerical integrator used and a number of schemes are tested and compared. Basic integrators like the Cauchy-Euler scheme fail to predict the acceleration accurately in a scenario with steep shock gradients. It is shown that a semi-implicit second-order scheme can remedy this problem allowing for using the method in hybrid magnetohydrodynamical jet simulations in order to predict their non-thermal emissions.

EP 13.4 Thu 18:30 ZEU/0160

Beginning a journey across the Universe: the discovery of extragalactic neutrino factories — •Lenz Oswald[1], Sara Buson[1], Andrea Tramacere[2], Leonard Pfeiffer[1], Alessandra Azzollini[1], and Marco Ajello[3] — [1]Lehrstuhl für Astronomie, Universität Würzburg, Emil-Fischer-Straße 31, 97074, Würzburg — [2]Department of Astronomy, University of Geneva, Ch. d'Ecogia 16, Versoix, 1290, Switzerland — [3]Department of Physics and Astronomy, Clemson University, Kinard Lab of Physics, Clemson, SC 29634-0978, USA

Identifying the sources of extragalactic neutrinos is one of the foremost challenges in the astrophysics field. Amongst the most promising candidate sources that can be associated there are blazars, active galactic nuclei hosting a relativistic jet pointed towards us. In this work, we provide evidence for an association between high-energy (>100TeV) IceCube neutrinos and a well-defined, sample of blazars (5th Roma BZCat catalog) in the Southern celestial Hemisphere. This results in a probability to find such correlation by chance that is as low as 2 x 10-6.

EP 13.5 Thu 18:45 ZEU/0160

Investigating the blazar-neutrino connection with public IceCube data — •Julian Kuhlmann and Francesca Capel — Max-Planck-Institut fuer Physik

The IceCube collaboration has found evidence for two active galactic nuclei, NGC 1068 and TXS0506+056, being sources of high energy neutrinos. However, catalog-based searches have yet to yield conclusive evidence for the role of different source populations in contributing to the observed astrophysical neutrino flux.

We present two open-source statistical analysis frameworks for the investigation of possible sources with publicly available IceCube data, which implement complementary frequentist and Bayesian approaches. We first demonstrate the capabilities of these frameworks on simulated data, and then apply them to investigate blazars as possible neutrino sources. We focus on bringing more information from multi-wavelength studies into the analyses, and studying both individual sources and the population as a whole. We discuss the advantages of the novel Bayesian approach and the implications of our results for the blazar-neutrino connection.

EP 14: Astrophysics: Stellar Astrophysics

Time: Friday 11:00–13:00 Location: HSZ/0004

Invited Talk EP 14.1 Fri 11:00 HSZ/0004

Unveiling the secrets of hot, massive stars with modern stellar atmosphere models — •Andreas A C Sander — Astronomisches Rechen-Institut, Zentrum für Astronomie der Universität Heidelberg, Heidelberg, Germany

Even in the time of multi-messenger astrophysics, it is the light from stars that mostly determines what we know about the Universe beyond our Earth. To decode the information that is imprinted in the starlight, we need to understand its origin in the outermost layers of the stars, the so-called stellar atmosphere. Modelling these transition layers allows us to translate our observations from small and big telescopes into a proper physical quantities, thereby enabling us to not just understand the stars themselves, but also their impact and interactions with their host environment and their role in the chemical evolution of the Universe.

My Emmy Noether research group at the ARI in Heidelberg focuses on the application and development of stellar atmosphere models for hot, massive stars. In my talk, I will briefly introduce the techniques and challenges of these expanding, non-equilibrium models as well as outline the concept for including a consistent hydrodynamic treatment. Afterwards, I will provide an overview about the observational and theoretical research efforts of my group, where we use the atmosphere models to unveil the secrets and impact of massive stars, ranging from the spectral analysis of individual stars and the theoretical investigation of radiation-driven winds to the prediction of stellar feedback in unresolved populations.

EP 14.2 Fri 11:30 HSZ/0004

Stellar oscillations in B supergiant stars. — •Julieta Paz Sanchez Arias[1], Matias Agustin Ruiz Diaz[2], and Peter Nemeth[1,3] — [1]Astronomical Institute, Czech Academy of Sciences. Ondrejov, Czech Republic — [2]Instituto de Astrofísica de La Plata. CONICET-UNLP. La Plata, Argentina — [3]Astroserver.org, Foter 1, 8533 Malomsok, Hungary

The evolution of massive stars depends on many stellar parameters and small changes in them during the evolution of the stars can yield widely diverging outcomes. Additionally, these parameters, such as the initial mass, metalicity, mass loss rate and the type and distribution of chemical mixing in their interiors are far from being firmly established. B supergiant stars are one peculiar group of massive stars that undergo stellar oscillations. These objects can be found in different evolutionary stages. The study of their spectra provides us with information on the surface chemical abundances left by their evolution and the current mass loss rate. On the other hand, the study of stellar oscillations is a powerful tool that allows to inspect the stellar interiors through the analysis of the light curves and numerical simulations of their evolution, interior and oscillations. In this work, we combine both tools to unveil the physical parameters involved in the evolution of 3 B supergiant stars in different stages of their evolution but sharing the same location in the Hertzsprung-Russell diagram.

EP 14.3 Fri 11:45 HSZ/0004

Super-kilonovae from Massive Collapsars as Signatures of Black Hole Birth in the Pair-instability Mass Gap — Daniel Siegel[1,2], •Aman Agarwal[1,2], Jennifer Barnes[3], Brian Metzger[3], Mathieu Renzo[3], and Ashley Villar[3] — [1]Perimeter Institute for Theoretical Physics, Waterloo, Ontario, N2L 2Y5, Canada — [2]Institute of Physics, University of Greifswald, D-17489 Greifswald, Germany — [3]Columbia Astrophysics Laboratory, Columbia University, New York, NY 10027, USA

The core collapse of rapidly rotating massive ~ 10 solar masses stars (collapsars), and the resulting formation of hyperaccreting black holes, comprise a leading model for the central engines of long-duration gamma-ray bursts (GRBs) and promising sources of r-process nucleosynthesis. Here, I will discuss the signatures of collapsars from progenitors with helium cores >~ 130Me above the pair-instability mass gap. The disk outflows can potentially generate a large quantity (up to >~ 50 solar masses) of ejecta, comprised of >~ 5-10 solar masses in r-process elements. Radioactive heating of the disk wind ejecta powers an optical/IR transient, with a characteristic luminosity ~ 10^42 erg/s and a spectral peak similar to kilonovae from neutron star mergers, but with longer durations >~1 month. These super-kilonovae herald the birth of massive black holes >~ 60Me and can populate the pair-instability mass gap from above. SuperKNe could be discovered through planned telescopes like Roman Space Telescope. Multiband gravitational waves of ~ 0.1-50 Hz from these systems are potentially detectable by proposed observatories out to hundreds of Mpc.

EP 14.4 Fri 12:00 HSZ/0004

General relativistic radiation hydrodynamics simulations of hypermassive star evolutions — •Ninoy Rahman, Andreas Bauswein, and Gabriel Martínez-Pinedo — GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

We investigate the evolutions of hypermassive neutron stars (HMNSs) formed by the mergers of binary neutron stars (BNSs) with initial gravitational masses of 1.35-1.35$M_\odot$, 1.362-1.362$M_\odot$, 1.292-1.4362$M_\odot$, 1.143-1.633$M_\odot$, and 1.37-1.37$M_\odot$ by 2D general relativistic hydrodynamical simulations. We employ the general relativistic hydrodynamics code NADA-FLD with energy-dependent three-flavor flux-limited diffusion neutrino transport to study the transiently formed HMNSs until their collapse to black holes (BHs). The newly born rapidly rotating HMNS with high temperatures and densities above nuclear saturation density is supported by the nuclear force, the thermal pressure, and the centrifugal force against gravity. We study the impact of the thermal and rotational properties of HMNSs on their lifetime. Additionally, we investigate the influence of viscous transport on the HMNS evolution. The lifetimes of HMNSs consider in this work vary from ∼50 ms to ∼150 ms. At Darmstadt, funding by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (ERC Advanced Grant KILONOVA No. 885281) is acknowledged.

EP 14.5 Fri 12:15 HSZ/0004

Weak Field Approximation of HAT-P-11s Magnetic Field via Stokes Polarimetry — •Andrew Rosenswie[1,2], Klaus Strassmeier[1,2], Silva Jaervinen[2], Thorsten Carroll[2], Martina Baratella[2], and Ilya Ilyin[2] — [1]Institut fuer Physik und Astronomie, Universitaet Potsdam, D-14476 Potsdam, Germany — [2]Leibniz-Institut fuer Astrophysik Potsdam (AIP), An der Sternwarte 16, D-14482 Potsdam, Germany

Presented in this work is the discovery of the magnetic field strength of the K dwarf star, HAT-P-11, which we measured in polarized light of the Stokes parameter V. The magnetic field was discovered to be 2.73 G. Our methodology can be applied to future polarimetric analyses of magnetically active stars via Stokes V polarimetry. Usage of echelle spectrographs with high spectral resolution allows for the determination of magnetic fields of stars and other celestial objects. We utilize the Potsdam Echelle Polarimetric and Spectroscopic Instrument (PEPSI), with spectral resolution R = 130 000. Due to the effects of orbital parameters of HAT-P-11 b, we predicted the detectability of a change of magnetic field strength of HAT-P-11 during the primary transiting eclipse of HAT-P-11 b, detected with PEPSI, consigned in the Large Binocular Telescope (LBT). By our discovery, it provides conclusive evidence via SVD profiles for deducing the magnetic field of a star known to be magnetically active for the past decade.

EP 14.6 Fri 12:30 HSZ/0004

An exact analytical solution for the weakly magnetized flow around an axially symmetric paraboloid, with application to magnetosphere models — •Jens Kleimann[1] and Christian Röken[2,3] — [1]Theoretische Physik IV, Ruhr-Universität Bochum, Germany — [2]Department of Geometry and Topology, Faculty of Science, University of Granada, Spain — [3]Lichtenberg Group for History and Philosophy of Physics, Institut für Philosophie, Universität Bonn, Germany

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

EP 14.7 Fri 12:45 HSZ/0004

Emulation of density and temperature structures in front of astrospheres: an incompressible approach — •Dieter H. Nickeler — Astronomical Institute, Czech Academy of Sciences, Ondrejov, Czech Republic

Stars with their winds traveling through the interstellar medium (ISM) can form stellar wind cavities called astrospheres, separating the ISM gas from the inner stellar wind material by the astropause. By using the Grad-Shafranov equation (GSE) formalism, based on the stream function method of Langrange and Stokes for incompressible hydrodynamics, we compute possible density and temperature profiles in the vicinity of the astropause. We start with a simple, single X-type stagnation point. By variation of the density function, where the density depends on the stream function only, it is possible to construct a huge variety of temperature profiles, with fixed pressure, automatically guaranteed by the fulfillment of the GSE. These profiles in density and temperature are essential for calculating expressions, with which synthetic radiation profiles from the regions in front of the astropause nose can be computed and compared to observations.

EP 15: Astrophysics: Cosmology

Time: Friday 14:00–15:30 Location: HSZ/0004

EP 15.1 Fri 14:00 HSZ/0004

Searching for sub-TeV neutrino counterparts for sub-threshold GW events — •Tista Mukherjee — Institute for Astroparticle Physics (IAP), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Neutrinos have been identified as promising cosmic messenger which can carry useful information about their astrophysical sources. Similarly, gravitational wave (GW) and photons can also serve the same purpose. By combining information from two or more than two messengers, we can perform multi-messenger studies which in principle, can provide us more complete information about an astrophysical site. So far, we have been able to correlate photons and neutrinos emitted from a blazar, now very famously known as the 'TXS blazar' in 2017. We also identified photons emitted from a binary neutral star (BNS) system, which was also the progenitor of GW, marked as GW170817 event by the LIGO-Virgo collaboration. But, a correlation between GW and neutrinos is yet to be identified, which serves as the motivation for my ongoing work. Here, I present the current status of it, where I am looking for sub-TeV neutrinos detected by IceCube, spatially and temporally correlated with sub-threshold GW events identified from the Gravitational Wave Transient Catalog (GWTC) 2.1.

EP 15.2 Fri 14:15 HSZ/0004

Determining H_0 without a distance ladder — •Hanna Belgardt and Dieter Horns — Institut für Experimentalphysik, Universität Hamburg, Luruper Chausseee 149, D-22761 Hamburg

The Hubble constant H_0 gives the present expansion rate of the universe. The value of H_0 is commonly determined using the cosmic distance ladder. Here, we present a method to measure H_0 via the distance-dependent attenuation of very-high energy (VHE) gamma-ray photons propagating in the extra-galactic background light (EBL).

We use a sample of VHE photon spectra of extragalactic sources including active galactic nuclei and gamma-ray bursts. We fit spectral models, which include the attenuation due to the pair production with the EBL photons. This attenuation can be characterized by an optical depth $\tau(H_0)$. We perform a fitting procedure to minimise the χ^2 and hence obtain an estimator for the Hubble constant.

Using the Domínguez et al. (2010) EBL model our preliminary analysis yields a best fit value of $H_0 = 76 \pm 6$ km/s/Mpc. This result is close and competitive to the value found with the cosmic distance ladder technique, e.g., $H_0 = 73(+2.6/-2.3)$km/s/Mpc (Kenworthy et al. 2022.) Final results will be shown at the conference.

EP 15.3 Fri 14:30 HSZ/0004

Modeling the extragalactic background light — •Devesh Chopra and Dieter Horns — Institut für Experimentalphysik, Universität Hamburg, Luruper Chausseee 149, D-22761 Hamburg

The Extragalactic Background Light(EBL) consists of the background light from all of the stars throughout the history of universe and hence contains a great deal of information about the evolution of galaxies from very early times up to the present. Although it is difficult to observe the EBL directly it could me modeled using various methods. Here, we present an updated model of the EBL computed directly from the global SFR.

We use the Starburst99(STScI) to generate simple stellar population spectra (SSPS) for which the IMF and metallicity are the most important parameters. The updated Cosmic Star-Formation History is used and a minimal set of assumptions are used so that it clearly connects the input physics to the output EBL. For all the input parameters of our model depending upon cosmological parameters a 737 cosmology is used but the resulting EBL intensity do not explicitly the cosmological parameters.

All the input parameters for our model are based on the most recent data hence yielding a very dependable EBL model. Our results provides a reliable lower-limit flux for the evolving Extragalactic Background Light up to redshift of 5 using minimum of parameters and assumptions. It allows a practical estimate of attenuation length for GeV-to-TeV gamma-rays. The comparison of our model with observed data points and other EBL models would be presented.

EP 15.4 Fri 14:45 HSZ/0004

Cross-Correlation of Artificial Diffuse Gamma-Ray Background Radiation and Corresponding Simulated Cosmic Shear — •Tristan Gradetzke and Stefan Fröse — TU Dortmund University

The cross-correlation of the diffuse gamma-ray background and cosmic-shear obtained from weak-lensing surveys yields the possibility to constrain dark-matter properties. This has been done already using Fermi-LAT data. Since Imaging Atmospheric Cherenkov Telescopes have a large effective area and are able to detect very-high energy gamma rays, the usage of their data for cross-correlation analyses is investigated. In this talk, a feasibility study, consisting of the cross-correlation of mock shear and diffuse gamma-ray background maps generated from a common mass distribution is discussed. We present the current state of the project.

EP 15.5 Fri 15:00 HSZ/0004

WISPFI: WISP searches on a fiber interferometer — •Josep Maria Batllori Berenguer, Yikun Gu, Rebecca Harte, Dieter Horns, Marios Maroudas, and Johannes Ulrichs — Institut für Experimentalphysik, Universität Hamburg, Luruper Chausseee 149, D-22761 Hamburg

The search for new physics at the sub-eV scale has been particularly active in the last years. Our principal aim is the detection of the QCD axion although our design is applicable to other axion-like particles (ALPs). We introduce a new table-top experiment to detect photon-axion conversion: WISP Searches on a Fiber Interferometer (WISPFI).

The experimental setup consists of a partial free-space Mach-Zehnder-type interferometer. In one of the arms, the fiber is coiled and placed inside the bore of a superconducting solenoid magnet (14 T, 140 mm diameter warm bore), where mixing occurs. The photon-axion oscillations would be detected by measuring changes in phase/amplitude.

For the detection at resonant mixing, we will use hollow-core photonic crystal fibers (HC-PCF), taking advantage of their unique guiding and optical properties. In particular, a large axion mass range (10 meV–100 meV) is achievable by regulating the air pressure inside the core of the HC-PCF. The effect of the core radius, wavelength and bending in the mode propagation is also discussed. Finally, implementations of squeezed light, higher-power laser or the application of an external electric field can improve the sensitivity even further.

EP 15.6 Fri 15:15 HSZ/0004

Searching for photon-ALPs mixing effect in AGN gamma-ray spectra — •Qixin Yu and Dieter Horns — Institut für Experimentalphysik, Universität Hamburg, Luruper Chausseee 149, D-22761 Hamburg

High energy gamma-rays propagating in external magnetic fields may convert into axion-like particles (ALPs). We use the energy spectra of 20 extra-galactic gamma-ray sources recorded during 10 years of Fermi-LAT observations. We define a test statistics based upon the likelihood ratio to test the hypothesis for a spectral model without vs. a model with photon-ALPs coupling. The conversion probability is calculated for fixed values of the mass and two-photon coupling of the pseudoscalar particle while the external magnetic field is characterized by the additional free parameters length scale s and average field strength B. We find for 20 of the 20 sources a favorable fit. The test statistics of the sources are combined and estimated to correspond to a significance of 2.7 sigma (test statistics summed in local maxima of all sources) and 4.9 sigma (global maxima). The locally best-fitting values of B and s fall into the range that is expected for large scale magnetic fields present in the intra-cluster medium of galaxy clusters and in large scale filaments.