# Extraterrestial Physics Division
# Fachverband Extraterrestrische Physik (EP)

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## Overview of Invited Talks and Sessions

(Lecture halls H5, H7, H8, and H9)

### Plenary Talk of the Extraterrestial Physics Division

| | | | | |
|---|---|---|---|---|
| PV VIII | Thu | 9:45–10:30 | Audimax | **Geophysics in Elysium Planitia - First Year Results from the InSight Mars Mission** — •Matthias Grott, Bruce Banerdt, Suzanne Smrekar, Tilman Spohn, Philippe Lognonne, Christopher Russel, Catherine Johnson, Don Banfield, Justin Maki, Matt Golombek, Domeniko Giradini, William Pike, Anna Mittelholz, Yanan Yu, Attilio Rivoldini |

### Invited Talks

| | | | | |
|---|---|---|---|---|
| EP 1.1 | Mon | 11:00–11:30 | H7 | **The onset mechanism and a physics-based prediction of large solar flares** — •Kanya Kusano |
| EP 1.4 | Mon | 12:00–12:30 | H7 | **Coronal bright points (small-scale loops) in the solar atmosphere** — •Maria S. Madjarska |
| EP 2.1 | Mon | 16:30–17:00 | H7 | **How can small satellites help advancing our physical understanding in heliospheric physics** — •Noé Lugaz, Christina O. Lee, Nada Al-Haddad, Réka Winslow, Dave Curtis, Rob Lillis, Toni Galvin |
| EP 3.1 | Tue | 11:00–11:30 | H8 | **Erforschung des Weltraumwetters am DLR Institut für Solar-Terrestrische Physik** — •Jens Berdermann |
| EP 4.1 | Tue | 16:30–17:00 | H8 | **Using multiple radar stations to examine atmospheric tides and their variability** — •Patrick Espy, Willem van Caspel, Robert Hibbins |
| EP 5.1 | Wed | 16:30–17:00 | H9 | **Planets are Places: Characterization of Other Worlds in the 2020s and Beyond** — •Laura Kreidberg |
| EP 6.1 | Thu | 11:00–11:30 | H8 | **The CoPhyLab: How to Study Comets in the Laboratory** — •Bastian Gundlach |
| EP 9.1 | Fri | 11:00–11:30 | H5 | **Exo-Kuiper Belts in Planetary Systems** — •Alexander Krivov |
| EP 9.5 | Fri | 12:15–12:45 | H5 | **The SOFIA legacy program FEEDBACK** — •Nicola Schneider, Alexander Tielens |

### Invited talks of the joint symposium What makes an exoplanet habitable (SYEP)

See SYEP for the full program of the symposium.

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|---|---|---|---|---|
| SYEP 1.1 | Wed | 14:00–14:30 | Audimax | **Requirements for Earth-like habitats** — •Helmut Lammer |
| SYEP 1.2 | Wed | 14:30–15:00 | Audimax | **Geological drivers of habitability** — •Raymond T. Pierrehumbert |
| SYEP 1.3 | Wed | 15:00–15:30 | Audimax | **Space Weather from an Active Young Sun and Its Impact on Early Earth** — •Vladimir Airapetian |
| SYEP 1.4 | Wed | 15:30–16:00 | Audimax | **Habitable zones around stars and the search for extraterrestrial life** — •James F. Kasting |

## Sessions

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|---|---|---|---|---|
| EP 1.1–1.4 | Mon | 11:00–12:30 | H7 | **Sun and Heliosphere I** |
| EP 2.1–2.8 | Mon | 16:30–18:45 | H7 | **Sun and Heliosphere II** |
| EP 3.1–3.5 | Tue | 11:00–12:30 | H8 | **Near Earth Space I** |
| EP 4.1–4.4 | Tue | 16:30–17:45 | H8 | **Near Earth Space II** |
| EP 5.1–5.5 | Wed | 16:30–18:00 | H9 | **Exoplanets and Astrobiology I** |
| EP 6.1–6.4 | Thu | 11:00–12:15 | H8 | **Planets and small Objects** |
| EP 7.1–7.3 | Thu | 14:00–14:45 | H8 | **Exoplanets and Astrobiology II** |
| EP 8 | Thu | 15:00–16:30 | MVEP | **Mitgliederversammlung AEF und DPG-EP** |
| EP 9.1–9.6 | Fri | 11:00–13:00 | H5 | **Astrophysics I** |
| EP 10.1–10.4 | Fri | 14:00–15:00 | H5 | **Astrophysics II** |

## Mitgliederversammlung der AEF und DPG-EP

2. September 2021 15:00–16:30 virtuell über ZOOM

https://zoom.us/j/98987066486?pwd=eFJ6cmhKKzlNdndyeXJvTTNtWkJ6Zz09

Begrüßung

Wahl eines Protokollführers

Feststellung der Beschlussfähigkeit

Kenntnisnahme des Protokolls der Mitgliederversammlung 2020

Bericht des Vorstandes

Höhepunkte und Veranstaltungen 2020, 2021

Bericht aus DPG und der DPG-Sektion Materie und Kosmos (SMuK)

Bericht des Schatzmeisters (AEF)

Bericht des Geschäftsführers (AEF)

Webseiten und Mitgliederverwaltung (AEF)

Entlastung des Vorstandes (AEF)

Bericht aus den Kommissionen

- Astrophysik
- Erdnaher Weltraum und Internationale Weltraumwetterinitiative ISWI
- Exoplaneten und Astrobiologie
- Planeten und kleine Körper
- Sonne und Heliosphäre

Kommissionsstruktur

Wahlen

- Vorsitz AEF und DPG-EP
- Zwei stellv. Vorsitzende AEF und DPG-EP
- Vorsitz und stellv. Kommission Astrophysik
- Vorsitz und stellv. Erdnaher Weltraum und ISWI
- Vorsitz und stellv. Exoplaneten und Astrobiologie
- Vorsitz und stellv. Planeten und kleine Körper
- Vorsitz Sonne und Heliosphäre

Sonstiges

# EP 1: Sun and Heliosphere I

Time: Monday 11:00–12:30 Location: H7

**Invited Talk** EP 1.1 Mon 11:00 H7

**The onset mechanism and a physics-based prediction of large solar flares** — •Kanya Kusano — Institute for Space-Earth Environmental Research, Nagoya University, Nagoya, Japan

What determines the onset of large solar flares is not yet well understood, although various models have been proposed. Therefore, their prediction mostly relies on empirical methods, and the accurate prediction of large flares is still difficult. Here, we report a new physics-based method, $\kappa$-scheme, that can predict imminent large solar flares (Kusano et al. 2020, Science). The $\kappa$-scheme is based on the theoretical model that a small magnetic reconnection between two sheared magnetic loops triggers the new ideal MHD instability, named the double-arc instability (Ishiguro & Kusano 2017, ApJ), driving a solar flare. We applied the $\kappa$-scheme to 198 active regions (ARs) with the largest sunspots recorded from 2010 to 2017 using the SDO SHARP dataset. While only 7 ARs in them produced solar flares larger than class X2, we demonstrated that the $\kappa$-scheme could clearly discriminate the 6 ARs in them out of the ARs not producing the large flare. It is also shown that the $\kappa$-scheme can predict even the precise position where a large flare begins. Based on the results, we conclude that magnetic twist flux density close to a magnetic polarity inversion line determines when and where solar flares may occur and how large they can be. Finally, we also discuss an attempt to extend the $\kappa$-scheme to predict eruptive flares and coronal mass ejections (Lin et al. 2020 & 2021, ApJ).

EP 1.2 Mon 11:30 H7

**Helicity Shedding by Flux Rope Ejection** — •Bernhard Kliem and Norbert Seehafer — Universität Potsdam, Institut für Physik und Astronomie

It has been suggested that magnetic helicity must be shed from the Sun by coronal mass ejections to limit its accumulation in each hemisphere. However, the efficiency of such helicity shedding and its dependence on source region parameters are not yet known. We perform a parametric simulation study of flux rope ejection from marginally stable force-free equilibria to address these questions. By varying the ratio of guide and strapping field and the flux rope twist, different ratios of self and mutual helicity are set and the onset of the torus or helical kink instability is obtained. The helicity shed is found to vary in a broad range from a minor to a major part of the initial helicity, with self helicity being largely or completely shed and mutual helicity, which makes up the larger part of the initial helicity, being shed only partly, up to a configuration-dependent base level. The torus-unstable configuration without a guide field and with only a relatively weak twist sheds nearly 2/3 of the initial helicity, while the highly twisted, kink-unstable configuration sheds only 1/4. The initial flux-normalized helicity of the former configuration is 0.21, a value presumably not far from the maximum helicity that a stable force-free flux rope equilibrium can contain. These results numerically demonstrate the conjecture of helicity shedding by coronal mass ejections and provide a first account of its parametric dependence.

EP 1.3 Mon 11:45 H7

**Flux rope reformation as a model for homologous solar flares and coronal mass ejections** — •Alshaimaa Hassanin[1,2], Bernhard Kliem[2], Tibor Toeroek[3], and Norbert Seehafer[2] — [1]Faculty of Science,Cairo University, Cairo, Egypt — [2]Institute of Physics and Astronomy, University of Potsdam, 14476 Potsdam, Germany — [3]3Predictive Science Inc., 9990 Mesa Rim Road, Suite 170, San Diego, CA 92121, USA

In this study we model for the first time a sequence of a confined and a full eruption, employing the flux rope reformed in the confined eruption as the initial condition for the ejective one. The full eruption develops as a result of imposed converging motions in the photospheric boundary which drive flux cancellation. In this process, a part of the positive and negative sunspot flux converge toward the polarity inversion line, reconnect, and cancel each other. Flux of the same amount as the canceled flux transfers to the flux rope, building up free magnetic energy. With sustained flux cancellation and the associated progressive weakening of the magnetic tension of the overlying flux, we find that a flux reduction of $\approx 8.9\%$ leads to the ejective eruption. These results demonstrate that homologous eruptions, eventually leading to a coronal mass ejection (CME), can be driven by flux cancellation.

**Invited Talk** EP 1.4 Mon 12:00 H7

**Coronal bright points (small-scale loops) in the solar atmosphere** — •Maria S. Madjarska — Max-Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany

When observed in extreme-ultraviolet (EUV) and X-rays, the million degree solar atmosphere, the solar corona, is predominantly populated by loops with a wide range of sizes. During the maximum of the solar activity cycle, bright active-region loops connect the opposite polarity strong magnetic fields of sunspots. Back in 1969 the first X-ray observations astonished the solar scientists by revealing that the solar corona that has been known as quiet and homogenous, is occupied by many bright point-like X-ray emission sources. They were named X-ray Bright Points (XBPs, now called Coronal Bright points, CBPs). Later, the Skylab observations showed that the XBPs actually represent dynamically evolving small-scale loops that confine plasma heated to up to 3 million degrees. It is now known that these small-scale loops are the main building blocks of the solar atmosphere outside active regions uniformly populating the solar atmosphere including active-region latitudes and coronal holes. I will present this essential class of solar phenomena, giving an overview of the current knowledge about their general, plasma, and magnetic properties as well as transient dynamic phenomena associated with them. The observationally derived energetics and the theoretical modelling that aims at explaining the CBP formation and eruptive behaviour, and their role in coronal heating and their contribution to the solar wind, will also be reviewed.

# EP 2: Sun and Heliosphere II

Time: Monday 16:30–18:45 Location: H7

**Invited Talk** EP 2.1 Mon 16:30 H7

**How can small satellites help advancing our physical understanding in heliospheric physics** — •Noé Lugaz[1], Christina O. Lee[2], Nada Al-Haddad[1], Réka Winslow[1], Dave Curtis[2], Rob Lillis[2], and Toni Galvin[1] — [1]Space Science Center, University of New Hampshire, Durham, NH, USA — [2]Space Science Laboratory, University of California, Berkeley, CA, USA

The past decade has witnessed a significant growth in the private space industry, with new companies building small spacecraft and offering private launch opportunities. Here, I will discuss recent developments and ongoing projects taking advantage of the lower costs of space hardware and the increase in launch opportunities. In particular, this may present opportunities and challenges on how we think of and design space missions, as new orbits and swarms of spacecraft become more important than new instrumentations. In addition, the desire to lower costs and obtain uniform datasests must be balanced by the need to continue promoting diversity in the centers, laboratories and universities building space hardware.

Interplanetary and space weather sciences may be especially ripe for such developments since they are dominated by large and costly missions (Solar Orbiter, Parker Solar Probe, SWFO-L1, L5 mission) and must often rely on single-spacecraft measurements to understand complex three-dimensional solar eruptions, shocks, solar wind structures and energetic particle events. I will end by discussing some recent concepts that may take advantage of smallsat technology to advance our understanding of interplanetary transients.

EP 2.2 Mon 17:00 H7

**The Solar Physics Research Integrated Network Group - SPRING** — •Markus Roth — Leibniz-Institut für Sonnenphysik, Freiburg

Large, high-resolution solar telescopes admit only a small field of view. However, context data showing the big picture of the dynamics and magnetism at different heights of the solar atmosphere are equally important to understand the Sun in general. Real-time information about the variation of surface velocity, magnetic field, and intensity at different solar layers is an essential input to fundamental solar physics and space weather prediction. There is a consensus that a worldwide distributed network of a suite of small, dedicated telescopes which observe the entire solar disk is needed to obtain these data on a continuous basis. In this talk, I will report about the current status of designing such a network * SPRING * which is currently developed under SOLARNET (High-resolution Solar Physics Network). The key scientific products of this facility will be arc-second resolution images of the Sun in various wavelengths, synoptic vector magnetic fields, synoptic surface velocity fields with high time cadence, and observations of transient events such as flares.

EP 2.3 Mon 17:15 H7

**Global solar coronal magnetic field modelling** — •Thomas Wiegelmann[1], Thomas Neukirch[2], Iulia Chifu[3,1], and Dieter Nickeler[4] — [1]Max-Planck-Institut für Sonnensystemforschung, Göttingen — [2]School of Mathematics and Statistics, University of St. Andrews, UK — [3]Institute for Astrophysics, University of Göttingen — [4]Astronomical Institute, Czech Academy of Sciences, Czech Republic

Computing the solar coronal magnetic field and plasma environment is an important research topic on it's own right and also important for space missions like Solar Orbiter and Parker Solar Probe to guide the analysis of remote sensing and in-situ instruments. In the inner solar corona plasma forces can be neglected and the field is modelled under the assumption of a vanishing Lorentz-force. Further outwards (above about two solar radii) plasma forces and the solar wind flow has to be considered. Finally in the heliosphere one has to consider that the Sun is rotating and the well known Parker-spiral forms. We have developed codes based on optimization principles to solve nonlinear force-free, magneto-hydro-static and stationary MHD-equilibria.

EP 2.4 Mon 17:30 H7

**3He measurements by the Suprathermal Ion Telescope on STEREO-A during solar cycle 24 and their association with electrons observed by SEPT and STE** — •Marlon Köberle[1], Radoslav Bucik[2], Bernd Heber[1], Andreas Klassen[1], and Linghua Wang[3] — [1]Christian-Albrechts-Universität zu Kiel, Germany — [2]Southwest Research Institute, San Antonio, USA — [3]Institute of Space Physics and Applied Technology, Peking University, Peking, China

$^3$He-rich solar energetic particle (SEP) events are characterized by a peculiar elemental composition with rare species like $^3$He or ultra-heavy ions tremendously enhanced over the solar system abundances. Previous studies have shown that the enormous enhancement of $^3$He up to a factor of $10^4$ above coronal abundances seems to be uncorrelated with the enhancement factor of heavier ions, indicating different acceleration mechanisms. The Suprathermal Ion Telescope (SIT) is a time-of-flight mass spectrometer designed to measure ions in the energy range of a few tens of keV up to several MeV per nucleon. The mass resolution of SIT doesnt allow to easily distinguish between $^3$He and $^4$He especially in cases of a low $^3$He to $^4$He ratio.

Here we present our semi-automatic detection approach that allowed us to identify 112 3He rich periods between 2007 and 2020, covering the whole solar cycle 24. A comparison between the Fe/O and $^3$He/$^4$He ratios showed no correlation supporting the present picture. Additionally an association of ≈60% of the periods could be found with in-situ electron measurements by STEREO-SEPT and STEREO-STE.

EP 2.5 Mon 17:45 H7

**First widespread solar energetic particle event observed by Solar Orbiter on 2020 November 29** — •Alexander Kollhoff[1], Athanasios Kouloumvakos[2], David Lario[3], Nina Dressing[4], Bernd Heber[1], and Robert Wimmer-Schweingruber[1] — [1]IEAP, Christian Albrechts-Universität zu Kiel, Kiel, Germany — [2]IRAP, Université Toulouse III - Paul Sabatier, CNRS, CNES, Toulouse, France — [3]NASA Goddard Space Flight Center, Heliophysics Science Division, Greenbelt, USA — [4]Department of Physics and Astronomy, University of Turku, Finland

With the launch of Solar Orbiter on 2020 February 10 a new era of multi-spacecraft observations opened up. An excellent example for the potentials of this era are the observations of the first widespread solar energetic particle event of solar cycle 25 on 2020 November 29. During this event relativistic electrons as well as protons with energies >50 MeV were observed by Solar Orbiter (SolO), Parker Solar Probe (PSP), the Solar Terrestrial Relations Observatory (STEREO)-A and multiple near-Earth spacecraft. The particle event was associated with an M4.4 class X-ray flare and accompanied by a coronal mass ejection (CME) and an extreme ultraviolet (EUV) wave as well as a type II and multiple type III radio bursts. Here we will present the in situ particle and remote sensing observations of this event and compare the timing of energetic particles observed at the four different locations with remote sensing observations of the solar source. We will particularly highlight the measurements of energetic electrons and protons by the Energetic Particle Detector (EPD) on board Solar Orbiter.

EP 2.6 Mon 18:00 H7

**Non-thermal electron velocity distribution functions generated by kinetic magnetic reconnection in the solar atmosphere** — •Xin Yao[1,2], Patricio Muñoz[2], and Jörg Büchner[2,1] — [1]Max Planck Institute for Solar System Research, 37077 Göttingen, Germany — [2]Centre for Astronomy and Astrophysics, Technical University of Berlin, 10623 Berlin, Germany

Magnetic reconnection in solar flares can generate non-thermal electron beams. Those accelerated electrons can, in turn, emit radio waves via kinetic instabilities. We aim at investigating the properties of those electrons beams that are relevant for those instabilities (sources of free energy) and their resulting radio emission. For this sake we utilize fully kinetic Particle-In-Cell simulations. Our results show that: (1) Parallel sources of free energy due to magnetized electrons are mainly generated in the diffusion region below/above the X point and separatrices, which can cause bump-on-tail instabilities and generate harmonics of electrostatic Langmuir waves. (2) Perpendicular sources of free energy due to unmagnetized electrons are formed in the diffusion and outflow region near the midplane of the reconnection, which can cause electron cyclotron maser instabilities and generate electrostatic Bernstein waves. In particular, a crescent-shaped EVDF in the velocity space perpendicular to local magnetic field is found. (3) The strength of external field has a negative influence on the formation of perpendicular sources of free energy. Our results allows us to remote diagnose some local plasma properties at the source regions of coronal magnetic reconnection via its radio emission.

EP 2.7 Mon 18:15 H7

**Heating of Helium ions in a low-beta multi-ions plasma** — •Zhaodong Shi[1], Patricio Munoz[1], Joerg Buechner[1], and Siming Liu[2] — [1]Center for Astronomy and Astrophysics, Berlin Institute of Technology — [2]Purple Mountain Observatory, Chinese Academy of Sciences

We study the heating of Helium ions ($^4He^{2+}$) in a multi-ions plasma consists of electrons, protons, and Helium ions via the 2D hybrid simulation using CHIEF code. Our results show that the eigenmodes of cold plasma waves in such a plasma can be recovered in our simulation. We find that Helium ions are heated both in the parallel and perpendicular directions (relative to the background magnetic field), while the perpendicular heating is preferred. Protons are also heated in the parallel direction, however, the perpendicular heating is very weak for them. And we find the significant parallel heating for both Helium ions and protons is due to the formation of ion beams and plateaus along the background magnetic field in their velocity distribution functions, while the perpendicular heating for Helium ions can be attributed to the increase of their perpendicular temperature. Our results are useful for understanding the preferential heating of $^3$He and other heavy ions in the $^3$He-rich solar energetic particle events, because Helium ions play a crucial role as the background ions regulating the behaviors of plasma in these events.

EP 2.8 Mon 18:30 H7

**Thermal-nonthermal energy partition in solar flares: current state and first results from STIX on Solar Orbiter** — •Alexander Warmuth — Leibniz -Institut für Astrophysik Potsdam (AIP)

Solar eruptive events are characterized by a complex interplay of energy release, transport, and conversion processes. A quantitative characterization of the different forms of energy therefore represents a crucial observational constraint for models of solar eruptions in general, as well as for magnetic reconnection, heating, and particle-acceleration processes in particular. This talk will focus on the energy partition

between the thermal plasma and the nonthermal particles and review recent studies that have tried to constrain this partition using X-ray, EUV, and bolometric observations. Theses studies have shown large discrepancies, and an effort will be made to identify the reasons for this. Finally, the first results on energy partition from the STIX instrument on Solar Orbiter will be presented.

## EP 3: Near Earth Space I

Time: Tuesday 11:00–12:30 Location: H8

**Invited Talk** EP 3.1 Tue 11:00 H8

**Erforschung des Weltraumwetters am DLR Institut für Solar-Terrestrische Physik** — •Jens Berdermann — DLR Institut für Solar-Terrestrische Physik, Kalkhorstweg 53, 17235 Neustrelitz

Das Weltraumwetter hat einen erheblichen Einfluss auf die Leistung und Zuverlässigkeit von weltraumgestützten und bodengestützten technologischen Systemen und kann hierdurch auch indirekt Menschenleben gefährden. Angesichts der wachsenden Bedeutung von Weltraumwetterinformationen ist 2019 die Gründung eines neuen DLR-Instituts am Standort Neustrelitz erfolgt. Das Institut für Solarterrestrische Physik (SO) befindet sich aktuell in der Aufbauphase und forscht im Bereich Weltraumwetter von den Grundlagen bis zur Anwendung. SO untersucht zeitlich variable Bedingungen auf der Sonne und im Sonnenwind sowie deren Wirkung auf das gekoppelte Ionosphären-Thermosphären-Magnetosphären-System und analysiert Weltraumwettereffekte auf betroffene Technologien in den Bereichen Kommunikation, Navigation, Luftfahrt, Satellitenbetrieb, bemannte Raumfahrt, elektrischer Netzbetrieb und Landvermessung. SO wird mit seinen Forschungsergebnissen zu wissenschaftlichen und technologischen Anwendungen z.B. im Bereich der Satellitenkommunikation und Navigation, der Erdbeobachtung, des Krisenmanagements, der Kommunikation für die Luftfahrt und der automatisierten Mobilität beitragen. Im Vortrag wird ein Überblick über die existierenden und geplanten Aktivitäten zum Thema Weltraumwetter am DLR Institut für Solar-Terrestrische Physik, sowie deren Einbindung in internationale Weltraumwetteraktivitäten gegeben.

EP 3.2 Tue 11:30 H8

**Exploring radiation belt electron precipitation** — •Alina S. Grishina[1,2], Yuri Y. Shprits[1,2,3], Michael Wutzig[1], Hayley J. Allison[1], Nikita A. Aseev[1,2], Dedong Wang[1], and Matyas Szabo-Roberts[1,2] — [1]GFZ, Potsdam, Germany — [2]University of Potsdam, Potsdam, Germany — [3]University of California, Los Angeles, Los Angeles, CA, USA

The near-Earth space environment is filled with charged particles gyrating around magnetic field lines, bouncing between the two hemispheres, and drifting around the Earth. The particle flux in this region can increase by orders of magnitude during geomagnetically active periods, driven by plasma sheet injections. Additionally, particles can be lost from the magnetic trapping region via precipitation into Earth's atmosphere, potentially affecting atmospheric chemistry and temperature. To explore this relationship further, we require information about the energy spectrum and energy range of the precipitating particles.

In this research, we concentrate on ring current electrons and investigate precipitation mechanisms using a numerical model based on the Fokker-Planck equation. Chorus wave-particle interactions are included using diffusion coefficients from Wang et al. [2019], and interactions with plasmaspheric hiss waves are included via the diffusion coefficients of Orlova et al. [2016]. The precipitating flux is calculated for discrete values of energy values from 1 to 300 keV. Model output is compared with observations from the POES satellite mission, that allows us to validate the calculated precipitating fluxes at different MLTs, over the ring current energy range.

EP 3.3 Tue 11:45 H8

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

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

Here we use the electron energy and flux data products from the Special Sensor Ultraviolet Spectrographic Imager (SSUSI) instruments on board the Defense Meteorological Satellite Program (DMSP) satellites. This formation of currently three operating satellites observes the auroral zone in the UV from which electron energies and fluxes are inferred in the range from 2 keV to 20 keV. We use these electron energies and fluxes to calculate ionization rates and electron densities in the lower thermosphere (≈90–150 km), and validate them against EISCAT ground-based measurements. We find that with the current standard parametrizations, the SSUSI-derived auroral electron densities (90–150 km) agree well with the ground-based measured ones.

EP 3.4 Tue 12:00 H8

**Dorman function of the DOSimetry TELescope (DOSTEL) count and dose rates aboard an aircraft** — •Lisa Romaneehsen, Sönke Burmeister, Bernd Heber, Konstantin Herbst, Johannes Marquardt, Christoph Senger, and Carsten Wallmann — Christian-Albrechts-Universität zu Kiel, Institut für Experimentelle und Angewandte Physik, Abteilung Extraterrestrische Physik, Deutschland

The Earth is continuously exposed to high energetic charged particles of galactic cosmic rays. The flux of these particles is altered by the magnetized solar wind in the heliosphere and the Earth's magnetic field. If cosmic rays hit the atmosphere, the formation of secondary particles depends on the atmospheric density above the observer. Therefore, the ability of a particle to approach an aircraft depends on its energy and the position and altitude of the aircraft.

The radiation detector of the detector system NAVIDOS (NAVIgation DOSimetry) is the DOSimetry Telescope (DOSTEL) measuring the count and dose rate in two semiconductor detectors. From 2008 to 2011 two instruments were installed in two aircraft. The access for energetic charged particles to the current position of the observer is given by the so-called cut-off rigidity. To analyze the data we corrected them for pressure variation by normalizing them to one flight level. We found that the normalization parameters vary with the solar modulation parameter and the cut-off rigidity as expected. These corrected data were utilized to determine the cut-off rigidity dependence by fitting the so called Dorman function to the observation.

EP 3.5 Tue 12:15 H8

**Dependence of the ISS DOSTEL Dorman function on the used external geomagnetic field** — •Hanna Giese, Sönke Burmeister, Bernd Heber, Konstantin Herbst, Lisa Romaneehsen, and Carsten Wallmann — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Kiel, Germany

The Earth is constantly hit by energetic particles originating from galactic sources. The flux of these particles is altered by the magnetized solar wind in the heliosphere and the Earth's magnetic field. For this reason, the ability of a particle to approach a spacecraft in Low Earth Orbit (LEO) depends on its energy and the position of the spacecraft within the Earth's magnetosphere, characterized by the so-called cut-off rigidity. This cut-off rigidity depends on the activity state of the heliosphere and magnetosphere that are described by models of different complexity. The DOSimetry TELescope (DOSTEL) aboard the International Space Station (ISS) monitors the radiation field within the European module Columbus, which varies with the geomagnetic positions. The correlation between the measured count rates and the corresponding cut-off rigidity is described by the Dorman function. In this contribution we compute cut-off rigidities along the ISS trajectory utilizing three Earth magnetosphere models during different solar and magnetospheric activity. As a result we find major differences between the resulting Dorman functions, which depend on and increase with the external solar wind pressure and exceed the uncertainty in intervals with a mean solar wind pressure of more than 3nPa.

## EP 4: Near Earth Space II

Time: Tuesday 16:30–17:45 Location: H8

**Invited Talk** EP 4.1 Tue 16:30 H8

**Using multiple radar stations to examine atmospheric tides and their variability** — •Patrick Espy[1,2], Willem van Caspel[1,2], and Robert Hibbins[1,2] — [1]Norwegian University of Science and Technology, Trondheim, Norway — [2]Birkeland Centre for Space Science, Bergen, Norway

Atmospheric tides and planetary waves (PWs) play an important role in shaping the day-to-day and seasonal variability of the Mesosphere-Lower-Thermosphere (MLT). Measurements of tidal and PW variability in the mid-latitude MLT have however remained sparse. This study uses a new analysis technique on the meteor radar winds from a longitudinal array of SuperDARN radars. These provide hourly measurements of the meridional wind at ~95km altitude from which we are able to investigate tides and PWs in the MLT at 65 degrees North. Using the array of SuperDARNs, we can identify east and westward traveling S1, S2 and S3 wave components over a broad range of frequencies spanning tidal to planetary wave oscillations. We present a study of the variability of the migrating and non-migrating tides and the longitudinal variability resulting from their interaction. Additionally we examine the variability of the 2 and 5-day waves in the MLT, and their interaction with tides during stratospheric warming events.

EP 4.2 Tue 17:00 H8

**The mid-to high-latitude migrating semidiurnal tide: Results from SuperDARN meteor wind observations and mechanistic simulations** — •Willem van Caspel[1,2] and Patrick Espy[1,2] — [1]Norwegian University of Science and Technology, Trondheim, Norway — [2]Birkeland Centre for Space Science, Bergen, Norway

Meteor wind observations of the migrating semidiurnal tide (SW2) made by a longitudinal chain of high-latitude SuperDARN radars are compared against simulations made using a mechanistic primitive equation model. The model is a three-dimensional, non-linear and time-dependent spectral model. The modeled background zonal mean zonal winds and temperatures are nudged to daily mean data from the Navy Global Environmental Model - High Altitude (NAVGEM-HA) meteorological analysis system up to ∼95 km altitude. The SW2 tide is forced using 3-hourly temperature tendency fields from the Specified Dynamics Whole Atmosphere Community Climate Model With Thermosphere and Ionosphere Extension (SD-WACCMX). To compare the model to observation, the model is sampled according to the meteor echo distribution of the SuperDARN radars at the locations of available measurements for the year 2015. Our model accurately reproduces the observed seasonal variations in the SW2 amplitude and phase. Model experiments are performed to investigate the role of the background atmosphere, tidal forcing, and dissipation terms in establishing the simulated SW2 tide. Notably, the dissipation terms include a seasonally varying mesospheric eddy diffusion, and a surface friction layer.

EP 4.3 Tue 17:15 H8

**Comparison of the chemical impact of extreme solar events with the Halloween solar proton event (SPE) in late October 2003 in the middle atmosphere using a 1D ion-chemistry model** — •Monali Borthakur[1], Thomas Reddmann[1], Miriam Sinnhuber[1], Ilya Usoskin[2], Jan-Maik Wissing[3], and Olesya Yakovchuk[3] — [1]Karlsruhe Institute of Technology, Karlsruhe, Germany — [2]University of Oulu, Oulu, Finland — [3]University of Rostock, Rostock, Germany

Strong eruptions in the Sun can accelerate protons to high energies, causing solar proton events (SPEs) and inducing geomagnetic disturbances. Such energetic particles can precipitate upon the Earth's atmosphere, mostly polar regions. We considered an extreme solar event combining an extreme SPE and a geomagnetic storm as derived from historical records of cosmogenic nuclides. The ionization rates (IRs) were calculated for strong directly observed events and scaled to represent extreme events. The chemical composition changes of different atmospheric components (Ozone, NOx, HOx, Cl) due to the extreme solar event and the Halloween SPE are compared in the middle atmosphere doing simulations in a 1D box model of the atmospheric neutral and ion composition. The motivation behind using this model is that it assumes canonical NOx/HOx per ion pair used in chemistry climate models (CCMs). Temperature, pressure and the initial state of the neutral atmosphere are input into the model that were obtained from the EMAC CCM using IRs from AIMOS. The IRs for the Halloween SPE were obtained from AISSTORM data.

EP 4.4 Tue 17:30 H8

**synthetic aperture radar satellite imaging of Earth's upper atmosphere and its potential application for upcoming Venus missions** — •Hiroatsu Sato[1] and Jun Su Kim[2] — [1]DLR Institute for Solar-Terrestrial Physics, Neustrelitz, Germany — [2]DLR Microwaves and Radar Institute, Wessling, Germany

Modern space-borne synthetic aperture radar satellite (SAR) can provide meter-scale resolution imaging of Earth*s ground surface. When SAR radio waves undergo propagation effects from the ionized atmosphere between the satellite and ground, the resulting SAR image contains information of the atmospheric plasma structures. Recent studies show that plasma density structures in Earth's ionosphere can be captured in L-band SAR images. Different SAR processing techniques using interferometry and sub-band data have been developed to extract the two-dimensional variation of plasma density irregularities We present case studies of SAR imaging of Earth ionospheric density and discuss its potential application for recently selected SAR missions for Venus whose ionosphere is not yet fully understood.

## EP 5: Exoplanets and Astrobiology I

Time: Wednesday 16:30–18:00 Location: H9

**Invited Talk** EP 5.1 Wed 16:30 H9

**Planets are Places: Characterization of Other Worlds in the 2020s and Beyond** — •Laura Kreidberg — Max Planck Institute for Astronomy, Königstuhl 17, 69117 Heidelberg

The past 25 years have revealed a diversity of exoplanets far beyond what was imagined from the limited sample in the Solar System. With new and upcoming observing facilities and a rapidly growing number of nearby planets, we are poised to bring this diversity into focus, with detailed follow-up characterization of the planets' atmospheres. In this talk, I will discuss frontier questions in exoplanet atmosphere characterization, including: what can we learn about a planet's formation conditions from its present-day atmosphere composition? Where is the dividing line between rocky and gaseous worlds? How are climate, atmospheric circulation, and cloud properties affected by the planet's irradiation environment? And finally, under what conditions do terrestrial planets maintain their atmospheres? Finally, I will conclude with my outlook on the search for biosignatures in the atmospheres of inhabited worlds.

EP 5.2 Wed 17:00 H9

**Spectral signature of atmospheric winds in high resolution transit observations** — •Engin Keles — Leibniz-Institut für Astrophysik Potsdam (AIP)

Exoplanet atmospheres show large diversity and especially Jupiter type exoplanets, the so-called hot and ultra-hot Jupiters which orbit their host star in close orbits, have been studied in detail. As those planets are tidally locked, atmospheric winds, such as zonal jet streams, become triggered due to the temperature difference between the day- and nightside. Spatially resolved absorption lines, for instance the NaD-lines, from high-resolution transit observations, could be a good tracer for such winds, giving insights into the dynamics of the planetary atmosphere. Comparing Na-lines detected on gas giants from different high-resolution transit observations, the findings suggest that the Na-line broadening is tendentially stronger for planets with lower equilibrium temperatures. If caused by zonal winds, this would hint that zonal winds become stronger on cooler planets introducing stronger line broadening within the investigated temperature range, being in agreement with theoretical expectations.

EP 5.3 Wed 17:15 H9

**The LIFE initiative - developing a space mission to search for life outside the Solar System** — •Sascha P. Quanz[1] and LIFE Initiative[2] — [1]Institute for Particle Physics and Astrophysics, ETH Zurich — [2]www.life-space-mission.com

In the context of its Voyage 2050 process the European Space Agency has recently identified the detection and characterization of rocky, temperate exoplanets as a potential science theme for a future L-class mission. Since its official kick-off in 2018, the LIFE initiative (LIFE=Large Interferometer For Exoplanets) has been working towards exactly that goal: to develop the science, the technology and a roadmap for an ambitious mid-infrared space mission that will allow humankind to detect and characterize the atmospheres of hundreds of nearby extrasolar planets including dozens that are similar to Earth. In this talk I will summarize the current status of the LIFE initiative, highlight the unprecedented scientific potential of the LIFE mission, discuss synergies with other ground- and space-based exoplanet instruments and missions, and elaborate on remaining technological challenges.

EP 5.4 Wed 17:30 H9

**Redox hysteresis of super-Earth exoplanets from magma ocean circulation** — •Tim Lichtenberg — Atmospheric, Oceanic and Planetary Physics, University of Oxford, Oxford, United Kingdom

From an astronomical perspective, planets that formed under similar conditions should exhibit comparable compositional trends, such as volatile inventory, which can be compared to hypothetical M-R relations. However, internal redox reactions may irreversibly alter the mantle composition and volatile inventory of terrestrial and super-Earth exoplanets, which can affect their outgassed atmospheres and decouple the initial accreted composition from long-term climate. The global efficacy of these mechanisms hinges on the transfer of reduced iron from the molten silicate mantle to the metal core. Using scaling analysis I demonstrate that turbulent diffusion in the internal magma oceans of sub-Neptune exoplanets can kinetically entrain liquid iron droplets and quench core formation. This suggests that the chemical equilibration between core, mantle, and atmosphere may be energetically limited by convective overturn in the magma flow. Hence, molten super-Earths possibly retain a compositional memory of their accretion path. Redox control by magma ocean circulation positively correlates with planetary heat flow, internal gravity, and planet size. The presence and speciation of remanent atmospheres, surface mineralogy, and core-mass fraction of atmosphere-stripped exoplanets may thus constrain magma ocean dynamics and can be probed by upcoming observational facilities.

EP 5.5 Wed 17:45 H9

**INCREASE - An updated model suite to study the INfluence of Cosmic Rays on Exoplanetary AtmoSpherEs** — •Konstantin Herbst[1], John Lee Grenfell[2], Miriam Sinnhuber[3], and Fabian Wunderlich[2] — [1]IEAP, Christian-Albrechts-Universität zu Kiel, 24108 Kiel, Germany — [2]PF, Deutsches Zentrum fuer Luft- und Raumfahrt (DLR), 12489 Berlin, Germany — [3]Institut fuer Meteorologie und Klimaforschung, Karlsruher Institut fuer Technologie (KIT), 76344 Eggenstein-Leopoldshafen, Germany

The first opportunity to detect indications for life outside of the Solar System may be provided already within this decade. However, the harsh stellar radiation and particle environment of planets in the habitable zone of their host stars could lead to photochemical loss of atmospheric biosignatures. A self-consistent model suite of combined state-of-the-art tools has been developed by Herbst et al. (2019) to study the impact of the radiation and particle environment on atmospheric particle interactions, composition, and climate interactions. Here we present our updated model suite to study a wide range of possible exoplanetary atmospheres and stellar environments tackling the following questions: (1) What processes determine whether (rocky) worlds around cooler stars can retain their atmospheres? (2) How do different atmospheres evolve for cool star systems?, and (3) How do results from our studies compare with observations? Thereby, we will focus on the impact of stellar activity on planetary climate, atmospheric escape, density and composition, surface radiation dose, and the impact on potential observables.

## EP 6: Planets and small Objects

Time: Thursday 11:00–12:15 Location: H8

**Invited Talk** EP 6.1 Thu 11:00 H8

**The CoPhyLab: How to Study Comets in the Laboratory** — •Bastian Gundlach — Institut für Geophysik und extraterrestrische Physik, Technische Universität Braunschweig, Deutschland

Comets are kilometer-sized objects, composed of different volatile and refractory species, i.e., ice and dust. They formed in the protoplanetary disc by the gravitational collapse of pebble clouds, typically consisting of mm- to cm-sized aggregates of dust and ice. After their formation, comets were scattered into the outer regions of our solar system and the bulk cometary material remained almost unaltered. Thus, comets are among the most primitive objects of our solar system. When a cometary nucleus enters the inner solar system, the cometary surface warms up and the volatile components start to sublimate. Particles, aggregates and chunks are then ejected off the cometary surface into space. This process leads to the formation of the cometary coma, the dust tail and the dust trail. However, the physical processes related to the ejection of material are still not understood. Laboratory experiments are one possible tool to investigate the activity of comets. This task is currently addressed by the CoPhyLab (Comet Physics Laboratory), an international collaboration among six Partner Institutes, with the aim to study the physical processes connected to cometary activity by various experiments and thermophysical modeling.

EP 6.2 Thu 11:30 H8

**Atmospheric processes affecting methane on Mars** — •John Lee Grenfell[1], Fabian Wunderlich[1,2], Miriam Sinnhuber[3], Konstantin Herbst[4], Ralph Lehmann[5], Markus Scheucher[2,6], Stefanie Gebauer[1], Gabriele Arnold[1], and Heike Rauer[1,2,7] — [1]Institut für Planetenforschung (PF), Deutsches Zentrum für Luft- und Raumfahrt (DLR), Berlin, Germany — [2]Technische Universität Berlin (TUB), Germany — [3]Karlsruhe Institute of Technology (KIT), Germany — [4]Kiel University (CAU), Germany — [5]Alfred Wegener Institute (AWI), Potsdam, Germany — [6]Now at: NASA Jet Propulsion Laboratory (JPL), Pasadena, USA — [7]Freie Universität Berlin (FUB), Germany

We investigate a range of atmospheric phenomena concerning their potential to address the Martian methane lifetime discrepancy. This refers to the over-estimate of the modelled lifetimes compared to observations by a factor of up to 600. We apply a newly developed atmospheric photochemical model where we vary in a Monte Carlo approach the chemical rate and eddy mixing coefficients within their uncertainties. Atmospheric pathways are identified and quantified in which methane is oxidized to its stable products. We also investigate the effect of air shower events due to galactic cosmic rays and solar cosmic rays. Our results suggest that the current uncertainty in chemical rates and transport together with seasonal changes in the water column and recently observed high abundances of chlorine in the Martian atmosphere can together account for a factor of 27.7 lowering (within 2-sigma) in the modelled Mars methane lifetime.

EP 6.3 Thu 11:45 H8

**Magnetfeldmodellierung der Merkurmagnetosphäre mit dem KTH-Modell** — •Kristin Pump und Daniel Heyner — IGEP, TU Braunschweig

Der Merkur ist der kleinste und innerste Planet unseres Sonnensystems und besitzt ein dipolartiges internes Magnetfeld. Hierdurch bildet sich eine Magnetosphäre aus, deren Strukturen Gegenstand aktueller Forschung sind. Die Magnetosphäre des Merkur ist im Vergleich zur der der Erde um ein Vielfaches kleiner, dynamischer und durch die nordwärtige Verschiebung des Dipols nicht symmetrisch in Nord-Süd-Richtung. Um die dort auffindbaren Strukturen und Prozesse zu verstehen, werden mithilfe der MESSENGER-Messdaten Modelle entwickelt, um beobachtete Signaturen erklären zu können und die anschließend dabei helfen sollen, die Magnetfeldmessungen der aktuellen BepiColombo-Mission noch genauer planen zu können.

In diesem Vortrag wird das KTH-Modell vorgestellt, ein modulares Modell, mit dem sich das Magnetfeld innerhalb der Merkurmagnetosphäre berechnen lässt. Dieses überarbeitete Modell beinhaltet zum ersten Mal ein realistisches Neutralschichtmodell, dass an den MESSENGER-Daten orientiert ist. Eine Residuenanalyse zeigt, dass mit diesem neuen Modul die Signaturen der feldparallelen Ströme und der zugehörigen Schließungsströme besser erkennbar sind. Darüber hinaus bietet das Modell Potential für eine Verbesserung der Hauptfeldbestimmung.

EP 6.4 Thu 12:00 H8

**New dynamo models with a stably stratified layer as an explanation for Mercury's unique magnetic field** — •Patrick Kolhey[1], Daniel Heyner[1], Johannes Wicht[2], and Karl-Heinz Glassmeier[1] — [1]Institut für Geophysik und extraterrestrische Physik, TU Braunschweig — [2]Max Planck Institute for Solar System Research, Göttingen

Since the discovery of Mercury's peculiar magnetic field it has raised questions about the dynamo process in the fluid core. The surface magnetic field is rather weak, strongly aligned to the planet's rotation axis and its magnetic equator is shifted towards north. Especially the latter characteristic is difficult to explain using common dynamo model setups. One promising model suggests a stably stratified layer right underneath the core-mantle boundary. As a consequence the magnetic field deep inside the core is efficiently damped by passing through the stably stratified layer due to a so-called skin effect. Additionally, the non-axisymmetric parts of the magnetic field are vanishing, too, such that a dipole dominated magnetic is left at the planet's surface. In this study we present new direct numerical simulations of the magnetohydrodynamical dynamo problem which include a stably stratified layer on top of the outer core, which can also reproduce the shift of the magnetic equator towards north. We explore a wide parameter range, varying mainly the Rayleigh and Ekman number under the aspect of a strongly stratified layer. We show which conditions are necessary to produce a Mercury-like magnetic field and give a inside about the planets interior structure.

## EP 7: Exoplanets and Astrobiology II

Time: Thursday 14:00–14:45 Location: H8

EP 7.1 Thu 14:00 H8

**Hidden water in magma oceans** — •Caroline Dorn[1] and Tim Lichtenberg[2] — [1]University of Zürich, Zürich, Switzerland — [2]University of Oxford, Oxford, United Kingdom

Over the past years, there has been huge progress in our understanding of the bulk properties of Super-Earth and Sub-Neptune exoplanets. Because hot and close-in planets are abundant in the exoplanet population, phase transitions in the interiors of small, dominantly rocky planets have come into sharper focus. Here, we use coupled structural models of the interior and atmosphere of up to super-Earth-sized exoplanets to explore the effect of water partitioning into the interiors of rocky planets inside the runaway greenhouse transition and calculate the effect on the total radius of planets compared to recent models that ignore this effect. The two end-member assumptions lead to a deviation in total planet radius on the order of 5-10%, which is within current accuracy limits for individual systems and will be statistically testable with next-generation transit surveys. In consequence, the inferred water content for a given observed radius of a specific planet may be underestimated by up to two orders of magnitude if volatile partitioning between planetary sub-reservoirs is not accounted for.

EP 7.2 Thu 14:15 H8

**Modeling the permittivity profile of Enceladus' tiger stripe region to a simulate radar exploration with an autonomous melting probe** — •Alexander Kyriacou, Pia Friend, Gianluca Boccarella, and Klaus Helbing — University of Wuppertal, Gaußstr. 20, 42119 Wuppertal, Germany

Enceladus possibly hosts extra-terrestrial life, due to the presence of a subsurface ocean. Plumes containing microscopic ice particles erupt from geysers into space, the latter of which mostly fall onto the surface and create a layer of deposited material. The geysers are fed by water-filled fractures connected to the ocean. These aquifers are a target for a future lander mission, Enceladus Explorer, carrying a self-navigating melting probe, using an integrated orbital, surface and subsurface radar system to map the intervening ice and localize the water pockets and potential hazards. The deposition of ice particles results in an in-homogeneous permittivity profile, and we quantify the effect this has on the positional uncertainty of radar. First, we predict the density, temperature and impurity level of Enceladus' surface ice. Using data from the Cassini mission deposition of ice particles is modelled, as well as densification processes such as sintering in the presence of heat from the geysers. We find that the ice grains remain unconsolidated on most of the surface and will only experience sintering within 1 km of active geysers. With the derived profile, we simulate radar propagation through the surface using ray-tracing and parabolic equation methods and reconstruct target positions. We compare the results with simulations of terrestrial glacier ice and field measurements.

EP 7.3 Thu 14:30 H8

**Response of a coupled climate-chemistry column model to step by step increases in insolation: Towards the simulation of a giant steam atmosphere at the close of the magma ocean period** — •Alexander Esau[1], Fabian Wunderlich[2], John L. Grenfell[2], and Heike Rauer[1,2,3] — [1]Centre for Astronomy and Astrophysics (ZAA), Berlin Institute of Technology (TUB), Hardenbergstr., 10623 Berlin, Germany — [2]Department of Extrasolar Planets and Atmospheres (EPA), Institute for Planetary Research (PF), German Aerospace Centre (DLR), Rutherfordstr. 2, 12489 Berlin, Germany — [3]Institut für Geologische Wissenschaften, Freie Universität Berlin, Malteserstr. 74-100, 12249 Berlin, Germany

Using the coupled climate-photochemical column model 1D-TERRA, we perform 11 scenarios varying the net, top-of-atmosphere incoming insolation (S) with values of S = 1 to S = 1.5. Results suggest surface temperature increases to 356 K mainly due to increasing insolation and associated greenhouse heating from enhanced water vapor via ocean evaporation. Surface pressure increases as a result from 1.02 bar (control) up to 1.54 bar in scenario 11 with the highest insolation. Near the tropopause, results suggest a warming of the cold trap and a weakening of the temperature inversion with increasing insolation. The cold trap and temperature inversion are no longer evident in the lower stratosphere in scenario 11, where a penetration of H2O into the stratosphere occurs consistent with tropospheric greenhouse heating and weakened upwards vertical mixing. We plan to investigate the photochemical and H-escape responses with our extensive chemical scheme.

## EP 8: Mitgliederversammlung AEF und DPG-EP

Time: Thursday 15:00–16:30 Location: MVEP

**https://zoom.us/j/98987066486?pwd=eFJ6cmhKKzlNdndyeXJvTTNtWkJ6Zz09 Meeting-ID: 989 8706 6486 Kenncode: 854932**

# EP 9: Astrophysics I

Time: Friday 11:00–13:00 Location: H5

**Invited Talk** EP 9.1 Fri 11:00 H5

**Exo-Kuiper Belts in Planetary Systems** — •Alexander Krivov — AIU, Friedrich Schiller University Jena, Germany

While planets are the most treasured outcome of the planet formation process, they are not the sole component of planetary systems. Another component is debris disks, which are belts of comets and asteroids akin to the Kuiper belt and asteroid belt of the Solar system. These belts also include dust that is produced by mutual collisions of comets and asteroids and other disintegration processes. It is thermal emission and stellar light scattered by that dust that make debris disks observable. This talk focusses on the most prominent, outer components of debris disks, which are considered analogous to the Kuiper belt. These "exo-Kuiper belts" are found around nearby stars nearly as frequently as planets, and more than 150 of them have been imaged by now. To illustrate how exo-Kuiper belts help us understand planetary systems, I will concentrate on two particular aspects. First, exo-Kuiper belts are sculpted and structured by planets in the systems. While possibilities of direct exoplanet detection still remain very limited, the debris disk structure seen in the resolved images can be used to pinpoint the perturbing planets and can also tell us where there are no planets. Second, being descendants of protoplanetary disks, exo-Kuiper belts serve as sensitive tracers of formation and evolution history of planetary systems. Interpreting debris disk observations with the help of models allows one, for instance, to constrain mechanisms of planetesimal accretion, formation of planets, and their subsequent dynamical evolution (scattering, migration) in the past.

EP 9.2 Fri 11:30 H5

**From Starspots to Stellar Coronal Mass Ejections - Revisiting Empirical Stellar Relations** — •Konstantin Herbst[1], Athanasios Papaioannou[2], Vladimir Airapetian[3,4], and Dimitra Atri[5] — [1]IEAP, Christan-Albrechts-Universität zu Kiel, Leibnizstr. 11, 24118 Kiel, Germany — [2]IAASARS, National Observatory of Athens, I. Metaxa & Vas. Pavlou St., 15236 Penteli, Greece — [3]NASA Goddard Space Flight Center, 8800 Greenbelt Rd, Greenbelt, MD 20771, USA — [4]American University, 4400 Massachusetts Ave NW, Washington, DC 20016, USA — [5]Center for Space Science, New York University Abu Dhabi, P.O. Box 129188, Abu Dhabi, UAE

Upcoming missions, including the James Webb Space Telescope, will soon characterize the atmospheres of terrestrial-type exoplanets in habitable zones around cool K- and M-type stars by searching for atmospheric biosignatures. Recent observations suggest that the ionizing radiation and particle environment from active cool planet hosts may be detrimental to exoplanetary habitability. Since no direct information on the radiation field is available, empirical relations between signatures of stellar activity, including the sizes and magnetic fields of starspots, are often used. Here, we revisit the empirical relation between the starspot size and the effective stellar temperature and evaluate its impact on estimates of stellar flare energies, coronal mass ejections, and fluxes of the associated stellar energetic particle events.

EP 9.3 Fri 11:45 H5

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

Magnetic reconnection is a process that occurs in plasmas, during which the topology of the magnetic field is changed in the presence of finite electrical resistivity. It is observed in solar flares, the Earth's magnetosphere as well as magnetic confinement devices.

We study a three-dimensional model of reconnection driven by magnetic field topology. In this framework, a high entanglement of magnetic field lines amplifies the influence of resistive effects and can thereby trigger reconnection. We investigate this model numerically using a finite-volume scheme to solve the magnetohydrodynamic (MHD) equations. This is done with a simple setup, in which an initially constant magnetic field is driven to high complexity. We study the dynamics of this system, the correlation between the field line entanglement and the occurrence of reconnection events, as well as the dependence of the reconnection rate on the magnetic diffusivity.

EP 9.4 Fri 12:00 H5

**Modern methods to solve nonlinear fluid equations – chances, issues and consequences for astrophysical fluid flows** — •Dieter Nickeler — Astronomical Institute, Czech Academy of Sciences, Ondrejov, Czech Republic

During the last decades several methods to solve nonlinear equations of hydrodynamics and magneto-hydrodynamics exactly have been developed. The idea is to construct a broad range of solution classes, to get insight into physical and topological properties of the usual physical fluid theories. We discuss the mapping theories such as non-canonical and algebraic transformations, based on the existence of at least one first integral of the corresponding vector field. These mappings enable us to construct fields of higher complexity out of much more simple solutions, e.g. nonlinear fields out of potential fields. In 2D the calculation of potential magnetic fields/flows is facilitated by solving the 2D Laplace equation via conformal mapping theory. In 3D, the Whittaker method is a generalization of conformal mappings, by applying complex analysis to solve the Laplace equation in 3D. Taking advantage of these general solutions, by determining a first integral of the corresponding vector field, the above mentioned transformations are used to construct nonlinear solutions. Due to the nonlinear transformations and the special choice of linear equilibria they are based on, specific topological characteristics, e.g. separatrices (astropauses) and physical effects, e.g. current sheets or vortex sheets, possibly triggering dissipation or magnetic reconnection, are calculated.

**Invited Talk** EP 9.5 Fri 12:15 H5

**The SOFIA legacy program FEEDBACK** — •Nicola Schneider[1] and Alexander Tielens[2,3] — [1]I. Physik. Institut, University of Cologne — [2]Leiden Observatory, Leiden — [3]Dep. of Astronomy, University of Maryland

Massive stars play a key role in the evolution of the interstellar medium (ISM) in galaxies because they impact the ISM through ionization, stellar winds, and supernova explosions. This stellar feedback regulates the physical conditions of the ISM, sets its emission characteristics, and ultimately governs the star formation activity.

I present here the first results of the SOFIA (Stratospheric Observatory for Infrared Astronomy) legacy program FEEDBACK. The project has been granted 96 hours observing time and started in 2019 in order to map Galactic star-forming regions in the emission lines of ionized carbon ([CII]) at 158$\mu$m and oxygen ([OI]) at 63$\mu$m. The major results so far are that (i) we discovered in all FEEDBACK sources expanding bubbles seen in the [CII] line, driven by stellar winds, that trigger further star formation, (ii) large amounts of cold [CII] that is ionized by cosmic rays and associated with atomic hydrogen, and (iii) dynamic signatures of molecular cloud collisions seen with [CII].

The FEEDBACK program thus fullfills its expectation to quantify the relationship between star formation activity and energy injection and the negative and positive feedback processes involved, and link that to other measures of activity on scales of individual massive stars, of small stellar groups, and of star clusters.

EP 9.6 Fri 12:45 H5

**Nebular kinematics and variability of the Galactic B[e] supergiant star MWC 137** — •Michaela Kraus — Astronomical Institute, Czech Academy of Sciences, Ondrejov, Czech Republic

The Galactic object MWC 137, with its large-scale optical bipolar ring nebula and high-velocity jet and knots, is a rather atypical representative of the B[e] supergiant class. To shed light on the physical conditions and kinematics of the nebula we performed multi-wavelength observations spreading from the optical to the radio regimes. Our data reveal a new bow-shaped feature at a distance of 80" from MWC 137. Moreover, we found that large amounts of cool molecular gas and warm dust embrace the large-scale optical nebula in the east, south, and west. The radial velocities of the nebula display a complex behavior but, in general, the northern nebular features are predominantly approaching while the southern ones are mostly receding. The electron density shows strong variations across the nebula with higher densities closer to MWC 137 and in regions of intense emission. In regions with high radial velocities the density decreases significantly. A disk of hot molecular gas revolves the star on small scales and possibly triggers the jet. The emission of this disk is reflected by dust arranged in arc-like structures and clumps surrounding MWC 137. Furthermore, we detect a period of 1.93 d in the time series photometry collected with the TESS satellite, which could suggest stellar pulsations. Other, low-frequency variability is seen as well. Whether these signals are caused by internal gravity waves in the early-type star or by variability in the wind and circumstellar matter currently cannot be distinguished.

## EP 10: Astrophysics II

Time: Friday 14:00–15:00 Location: H5

EP 10.1 Fri 14:00 H5

**Structure formation in isothermal supersonic plasmas: magnetic helicity inverse transfer** — •Jean-Mathieu Teissier[1] and Wolf-Christian Müller[1,2] — [1]Technische Universität Berlin, Berlin, Deutschland — [2]Max-Planck/Princeton Center for Plasma Physics, Princeton, NJ, USA

The interstellar medium exhibits large-scale magnetic structures and a wide range of turbulent sonic Mach numbers (from subsonic to Mach numbers of order 10 and beyond), with different turbulent drivers. A mechanism to explain the presence of large-scale structures is the inverse transfer of magnetic helicity, a quadratic ideal invariant describing some topological aspects of the magnetic field. Its inverse transfer has been investigated in direct numerical simulations (DNS), up to this work, only in incompressible and low Mach number cases. We present results from DNS in the isothermal case with Mach numbers ranging up to about 10 with different turbulence drivers and point out differences and similarities with the incompressible case, in particular with respect to spectral scaling laws and Fourier shell-to-shell transfers.

Our work suggests that some incompressible dynamical balances are extended in the supersonic regime and that the driving type affects the dynamics more significantly than the turbulent Mach number alone.

EP 10.2 Fri 14:15 H5

**Der AGN TXS 0506+056 als Quelle hochenergetischer Neutrinos** — •Maximilian Albrecht und Felix Spanier — Universität Heidelberg - ITA

Aktive Galaktische Kerne sind bereits seit längerer Zeit in der Diskussion als mögliche Beschleuniger hochenergetischer kosmischer Strahlung. Als der Blazar TXS 0506+056 infolge einer groß angelegten Multimessenger-Kampagne als Quelle des vom IceCube-Teleskop 2017 detektierten hochenergetischen Muon-Neutrinos (IceCube-170922A) identifiziert wurde, war dies ein erster Hinweis auf mögliche Korrelationen der erhöhten spektralen Aktivität solcher Quellen und ihrer Neutrinoproduktion. Studien dieser Korrelation durch Simulation der im Jet stattfindenden Beschleunigungsprozesse und ihrer Photonen- und Neutrinoemission, lassen daher durch den Vergleich mit den beobachteten Flüssen Rückschlüsse auf die Zusammensetzung des Jet-Plasmas zu.

In diesem Beitrag sollen die Ergebnisse einer Modellierung des Ausbruchs von TXS 0506+056 aus dem Jahr 2017 anhand der vorhandenen Multimessenger-Daten mit dem Zwei-Zonen-Modell UNICORN-0D vorgestellt werden. Im Gegensatz zu vorherigen Modellen wurde dabei die Emission der Host-Galaxie berücksichtigt. Dann konnte mittels Dopplerfaktor, Magnetfeld und den Protron- und Elektrondichten der Quelle die erwartete IceCube Detektion ermittelt und mit den Daten verglichen werden.

EP 10.3 Fri 14:30 H5

**The MAGIX Trigger Veto System** — •Sebastian Stengel for the MAGIX-Collaboration — Johannes Gutenberg University Mainz, Institute for Nuclear Physics, Germany

The MAGIX setup will be used for Dark Photon searches using the visible as well as the invisible decay channel. The MAGIX trigger veto system will enable the fast timing characteristics needed for investigating the visible Dark Photon decay channel A* -> e+e-. It will further be used for energy-loss measurements and will provide the basic hit and position information for the triggered readout of the MAGIX time projection chamber. The MAGIX trigger veto system will consist of one segmented trigger layer of plastic scintillator bars and a flexible veto system of additional scintillation detectors and lead absorbers placed beneath the trigger layer. The data readout will use the ultrafast preamplifier-discriminator NINO chip developed for use in the ALICE detector followed by FPGAs programmed as TDCs.

EP 10.4 Fri 14:45 H5

**Representation of Subatomic Particles as focal points and the repercussion on extra-terrestrial gravitation.** — •Osvaldo Domann — Stephanstr. 42, 85077 Manching

An approach is presented where a subatomic particle (SP) is represented as a focal point of rays of Fundamental Particles (FPs) that move from infinite to infinite. The energy of a subatomic particle is stored at its FPs as rotation defining angular momenta. With this representation all SPs interact permanently through the angular momenta of their FPs, according to the Mach principle that postulates that physical laws are determined by the large-scale structure of the universe. The approach explains gravitation as the result of the physical reintegration of migrated electrons and positrons to their nuclei. Gravitation is so composed of a Newton and an Ampere component, with the Newton component dominant at sub galactic distances and the Ampere component at galactic distances. A positive Ampere component explains the speed flattening of galaxies and a negative Ampere component the expansion. As with this approach SPs are permanently interacting through their FPs, there is no need to introduce carrier particles in the theoretical model to explain their interactions, carriers like gluons, gravitons, W and Z Bosons, etc. All four known forces are the result of electromagnetic interactions. More at: www.odomann.com