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 158μm and oxygen ([OI]) at 63μm. 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.