EP 14: Astrophysics II

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

EP 14.1 Fri 11:00 ZHG101

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

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

EP 14.2 Fri 11:15 ZHG101

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

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

EP 14.3 Fri 11:30 ZHG101

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

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

EP 14.4 Fri 11:45 ZHG101

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

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

EP 14.5 Fri 12:00 ZHG101

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

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

EP 14.6 Fri 12:15 ZHG101

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

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