EP 7: Fundamental Physics

Zeit: Dienstag 15:00–16:15 Raum: AKM

EP 7.1 Di 15:00 AKM

A new particle invariant suggested by frozen-in magnetic field lines at the solar wind termination shock — •Mark Siewert and Hans-Jörg Fahr — Argelander-Institut für Astronomie, Uni Bonn

Among other concepts, Magnetohydrodynamics introduces the frozen-in field condition, which causes magnetic field lines to be convected along with the plasma flow velocity $\vec{U}$. However, in astrophysical boundary layers (i.e. shock waves), deceleration is discontinous, and therefore, it is highly nontrivial to describe how the gyrating ions will react to this. In the past, we have studied this problem under the assumption that the classical electromagnetic invariant, the magnetic moment, is still conserved in the transition layer of the shock, which, however, results in too weak temperature gains when compared to the solar wind termination shock data taken by the Voyagers. We now present a new approach, based on the concept that decelerated frozen-in field lines lead to a local overshooting configuration, which modifies the classical gyrational motion, ultimately leading to a better agreement with the solar wind termination shock data.

EP 7.2 Di 15:15 AKM

Compressible MHD turbulence — •Christian Vogel[1,2] and Wolf-Christian Müller[1] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [2]Excellence Cluster Universe, Technische Universität München, Boltzmannstr. 2, D-85748, Garching, Germany

Understanding compressible MHD turbulence is key to describing compressible magnetized turbulent flows observed in astrophysical plasmas such as the interstellar medium. We present spectral scaling relations of supersonic and super-Alfvénic compressible MHD turbulence. Results of numerical simulations of the isothermal compressible MHD equations are compared to predictions of the Fleck model of compressible hydrodynamic turbulence. This includes self-similar scaling exponents of the turbulent velocity, the kinetic energy, and the density-weighted velocity over a range of sonic Mach numbers from subsonic flows to highly supersonic flows. Random large-scale driving of the velocity field and the magnetic field is used to keep the system in a statistically steady state. Additionally, we discuss the differing role of the non-linear turbulent energy transport in compressible and incompressible MHD turbulence.

EP 7.3 Di 15:30 AKM

Surprises in the theory of anisotropic magnetohydrodynamic turbulence — •Wolf-Christian Müller[1] and Roland Grappin[2] — [1]Max-Planck-Institut für Plasmaphysik — [2]LUTH, Observatoire de Paris

A new approach toward the analysis of high-Reynolds-number direct numerical simulations of incompressible magnetohydrodynamic (MHD) turbulence subject to a strong mean magnetic field has led to unexpected results: the scaling of one dimensional spectra taken along rays passing through the origin of Fourier space is independent of the rays' orientation with respect to the mean magnetic field direction; the spectral amplitude variation with respect to the angle between a ray and the mean magnetic field can be eliminated by normalization with an angle-dependent dissipation wavenumber. Thus the anisotropy of MHD turbulence permeated by a strong mean magnetic field does *not* appear as direction dependent scaling but rather as a direction dependent Reynolds number. These findings invalidate most present phenomenologies for macroscopically anisotropic MHD turbulence which are based on the critical balance argument.

EP 7.4 Di 15:45 AKM

Nonlinear Triad Interactions in 3D-MHD Turbulence — •Yasser Rammah and Wolf-Christian Müller — Max-Planck-Institut für Plasmaphysik, 85748 Garching

Nonlinear triad interactions in incompressible three-dimensional magnetohydrodynamic (MHD) turbulence are studied by analyzing high-resolution direct numerical simulations of decaying isotropic (512^3 grid points) and forced anisotropic ($1024^2 \times 256$ grid points) turbulence. An accurate approach of analyzing nonlinear turbulent interactions is presented. It involves the direct numerical examination of every wavenumber triad that is associated with the nonlinear terms in the differential equations of MHD in the inertial range of turbulence. The technique allows to compute spectral energy transfer and energy fluxes, as well as the spectral locality property of energy transfer. To this end, the statistical distribution of the energy transfer over all triads is examined with regard to the shape of the underlying wavenumber triads. Results show that the total, kinetic, and magnetic energy transfer is local in decaying macroscopically isotropic MHD turbulence. In anisotropic MHD turbulence subject to a strong mean magnetic field the nonlinear transfer is generally weaker and exhibits a moderate increase of nonlocality in both perpendicular and parallel directions compared to the isotropic case. These results are in contradiction with previous numerical results, but they support recent mathematical findings which also claim the locality of nonlinear energy transfer in MHD turbulence.

EP 7.5 Di 16:00 AKM

Anomalous momentum transport and plasma heating in collisionless return-current beam plasma system: multi-fluid and kinetic approaches — •Kuang Wu Lee and Jörg Büchner — Max-Planck-Institut für Sonnensystemforschung, Max-Planck-Str. 2, 37191 Katlenburg-Lindau, Germany

The anomalous transport in a one dimensional, collisionless return-current beam plasma system is studied by means of electrostatic Vlasov and three-fluid simulations. A current-free condition is applied and mimics the counter-streaming electron beams. The electron bulk drifts are dissipated due to anomalous momentum transport and electron heating. The spectrum of generated electric field fluctuations proves the charge separation effects play a major role as anomalous transport in the multi-fluid plasma. To investigate the dissipation mechanism in kinetic scale, a 1D electrostatic Vlasov code simulation is performed with same macroscopic plasma parameters. The comparison of the two different approaches shows that a much stronger drift relaxation takes place in the multi-fluid plasma approach. It was found that it spends within the same time span ($\triangle t \approx 700\ \omega_{pe}^{-1}$) to reach the same drift relaxation levels in two different approaches. This hints that charge-separation is a common mechanism of generating anomalous transport in multi-fluid plasma descriptions. By carrying out a wave-particle interaction analysis, it was shown that in kinetic plasma description Landau damping play a role to stop further current dissipation. In conclusion we obtained that an additional anomalous transport term is required for a complete multi-fluid plasma description.