P 2: Astrophysical Plasmas

Time: Monday 14:45–15:50 Location: KH 01.020

P 2.1 Mon 14:45 KH 01.020

Astrophysical perpendicular shocks for intermediate Mach numbers — •Valentine Devos, Artem Bohdan, and Frank Jenko — Max Planck Institute for Plasma Physics, Garching bei München

This project investigates the microphysics and structure of collisionless shocks from planetary to astrophysical scales, focusing on the intermediate Mach-number regime. Using fully kinetic Particle-In-Cell simulations, we study the transition from low-Mach instabilities (whistler precursors, modified two-stream modes) to high-Mach regimes dominated by Weibel and Buneman instabilities.

A key objective is to characterise electron kinetics and the conditions enabling efficient acceleration through Diffusive Shock Acceleration (DSA), Shock Surfing (SSA), and Shock Drifting (SDA).

To identify and track instabilities, we compute theoretical whistler anisotropy thresholds from particle distributions, evaluate linear growth rates for whistler and Weibel modes, and compare them with simulation results. We also derive dispersion relations to link the observed wave activity to the underlying kinetic processes.

Overall, this work clarifies how micro-instabilities regulate electron heating and acceleration across Mach numbers, connecting low- and high-Mach collisionless shocks in space and astrophysical plasmas.

P 2.2 Mon 15:10 KH 01.020

Turbulence in Molecular Clouds — •Christian Heppe[1], Alexei Ivlev[2], Frank Jenko[1], and Daniele Villa[1] — [1]Max-Planck-Institute for Plasmaphysics, Garching — [2]Max-Planck-Institute for Extraterrestrial Physics, Garching

The bulk mass of gas in the interstellar medium (ISM) is located in so called Molecular Clouds (MCs), which are dense and cold environments also known as nurseries of stars. Due to highly energetic Cosmic Rays (CRs) these dense gases are still weakly ionized even deep into their centers. We investigate the effect of this partial ionization by means of 3D two-fluid MHD turbulence simulations in which we model the neutral and ionized gas coupled by a collisional drag term explicitly. As the coupling is collisional we expect, on scales smaller than their collision frequencies, the gases to increasingly decouple while on larger scales the gases to move in unison. This has direct impacts on linear MHD waves and consequently on the turbulent cascade in these systems. We investigate the impact of the decoupling on the energy transfer over scales in the turbulent cascade, attempt to generalize the characteristics of turbulence in these weakly ionized environments and present the implications for star formation and CR transport.

P 2.3 Mon 15:35 KH 01.020

Particle acceleration at oblique high-Mach-Number shocks propagating in a turbulent medium — •Eloise Moore[1], Karol Fulat[2], Mahmoud Al-Awashra[3], Michelle Tsirou[3], and Martin Pohl[1,3] — [1]Institute of Physics and Astronomy, University of Potsdam, D-14476 Potsdam, Germany — [2]Department of Astronomy, University of Wisconsin-Madison, Madison, WI 53706, USA — [3]Deutsches Elektronen-Synchrotron DESY, Platanenallee 6, 15738 Zeuthen, Germany

Astrophysical collisionless shocks are efficient particle accelerators that require some pre-acceleration mechanism in order for electrons to participate in diffusive shock acceleration. The particle-in-cell (PIC) method provides a kinetic description of a system from first principles of collisionless plasma. Using the PIC code, THATMPI, we perform novel simulations of oblique non-relativistic high-Mach-number shocks propagating into an upstream containing pre-existing decaying turbulence. Such turbulence consists of perturbations in the magnetic field varying in amplitude, and a self-consistent current driven by the ions to limit the phase speed to low levels. We investigate the role of turbulence in modifying the shock structure, plasma instabilities and ultimately particle acceleration, by comparing our results to simulations with a homogeneous upstream.