P 15: Astrophysical Plasmas

Time: Wednesday 16:15–17:45 Location: ZHG102

P 15.1 Wed 16:15 ZHG102

Can a Compressible Jet Sustain Significant Turbulence in a (Magnetized) Turbulent Environment? — •David Kube[1], Gabriele Camerlengo[2], Wolf-Christian Müller[1,3], and Jörn Sesterhenn[2] — [1]Centre of Astronomy and Astrophysics, Technische Universität Berlin — [2]Chair of Applied Mechanics and Fluid Mechanics, Universität Bayreuth — [3]Max-Planck/Princeton Center for Plasma Physics

The interaction of turbulence and jets is ubiquitous throughout the universe. A particularly intriguing example is the supersonically turbulent ISM, where the underlying driving mechanisms for turbulence remain insufficiently understood. Protostellar jets are promising candidates, as they are seen to impact the interstellar gas dynamics on parsec scales. Therefore, we aim to investigate the universal characteristics of jet-turbulence interactions using a simplified setup to identify fundamental mechanisms of potential importance for more complex configurations like star and structure formation. To address if a compressible jet can sustain turbulence in a decaying turbulent medium, we perform DNS of a jet impacting a turbulent cloud covering various combinations of the jet Mach number M_j and the RMS Mach number of the cloud $M_{t,\mathrm{rms}}$. Furthermore, the influence of the magnetic field is assessed by comparing results from MHD simulations with those obtained by solving the compressible Navier-Stokes equations. In this talk, we discuss the numerical setup being used in the study and show first results demonstrating that for specific combinations of M_j and $M_{t,\mathrm{rms}}$, notable interaction between the jet and the cloud occurs.

P 15.2 Wed 16:30 ZHG102

Nonmetal-to-metal transition in liquid hydrogen using density functional theory and the HSE XC functional — Armin Bergermann, Lucas Kleindienst, and •Ronald Redmer — Institut für Physik, Universität Rostock, D-18051 Rostock

We investigate the first-order liquid-liquid phase transition in fluid hydrogen, which is accompanied by a nonmetal-to-metal transition. We use a combination of density functional theory for the electrons and molecular dynamics simulations for the ions. By employing the nonlocal Heyd-Scuseria-Ernzerhof (HSE) exchange-correlation functional, we accurately determine the equation of state and the corresponding coexistence line. Additionally, we calculate the electrical conductivity using the Kubo-Greenwood formula and find jumps in the coexisting region, which is characteristic of a first-order transition. Our new predictions are compared with previous theoretical results and available experimental data [1]. Thereby, we find that the strongly constrained and appropriately normed (SCAN) exchange-correlation functional provides an excellent balance between computational cost and accuracy. [1] A. Bergermann, L. Kleindienst, R. Redmer, J. Chem. Phys. (accepted).

P 15.3 Wed 16:45 ZHG102

Marginal Role of the Electrostatic Instability in the GeV Scale Cascade Flux from 1ES 0229+200 — •Martin Pohl[1,2] and Mahmoud Alawashra[1] — [1]Deutsches Elektronen-Synchrotron DESY, Platanenallee 6, 15738 Zeuthen, Germany — [2]Institute for Physics and Astronomy, University of Potsdam, D-14476 Potsdam, Germany

TeV gamma rays from blazars spawn relativistic pair beams that should generate detectable GeV-scale cascade emission, yet this component is absent in the observed spectra of some blazars. One interpretation is the deflection of the electron-positron pairs by a weak intergalactic magnetic field. Alternatively, electrostatic beam-plasma instabilities could drain the beam energy before the pairs produce the cascade emission. Recent studies suggest that particle scattering is the primary feedback of these plasma instabilities, rather than energy loss. In this work, we quantitatively assess the arrival time of secondary gamma rays at Earth as a function of the beam scattering by the electrostatic instability. Our findings reveal that the time delay of the GeV secondary cascade arrival due to instability broadening is on the order of a few months, which is insufficient to account for the missing cascade emission in blazar spectra. In this study, we have not yet included linear Landau damping of the plasma oscillations caused by the MeV-band cosmic-ray electrons. The impact of this damping on the nonlinear evolution of the beam-plasma system will be studied in future work.

P 15.4 Wed 17:00 ZHG102

Particle acceleration at oblique high-Mach-Number shocks propagating in a turbulent medium — •Eloise Moore[1], Karol Fulat[2], 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]DESY, Platanenallee 6, 15738 Zeuthen, Germany

Astrophysical collisionless shocks are efficient particle accelerators, however, some pre-acceleration mechanism is needed for electrons to participate in diffusive shock acceleration. We investigate how pre-existing turbulence could modify the shock structure, plasma instabilities, and ultimately particle 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 performed novel simulations of oblique non-relativistic high-Mach-number shocks propagating into an upstream with pre-existing turbulence. We consider decaying compressive turbulence with density fluctuations of amplitude around 15%, consistent with measurements of the local interstellar medium. We find that the turbulence was able to modify the properties of the shock-reflected electrons that drive plasma instabilities ahead of the shock front. While we find that the energy spectrum of the downstream electrons shows a non-thermal tail for both homogeneous and turbulent simulated environments, the latter indicates more efficient electron acceleration. We conclude that the presence of turbulence plays a key role in the pre-acceleration mechanisms at play.

P 15.5 Wed 17:15 ZHG102

Measuring the Free-Free Opacity of Hydrogen at Stellar Interior Conditions Using the National Ignition Facility — •Samuel Schumacher[1], Julian Lütgert[1], Ronald Redmer[1], Mandy Bethkenhagen[8], Laurent Masse[7], Dirk Gericke[2], Siegfried Glenzer[5], Tilo Döppner[6], Tina Ebert[6], Gareth Hall[6], Otto Landen[6], Markus Schölmerich[6], Charles Starrett[3], Nathaniel Shaffer[4], Laurent Divol[6], Benjamin Bachmann[6], Steve MacLaren[6], Clement Trosseille[6], Shahab Khan[6], and Dominik Kraus[1] — [1]Universität Rostock — [2]Warwick University — [3]Los Alamos National Laboratory — [4]University of Rochester — [5]SLAC — [6]Lawrence Livermore National Laboratory — [7]CEA — [8]Université Lyon

The opacity of stellar matter is critical for modeling stellar interiors, primarily composed of hydrogen and helium. It determines where convection becomes the dominant energy transport mechanism.

Stellar interior modeling is challenging due to dense plasma conditions, with temperatures of hundreds of eV and densities 800 times that of solid matter. These conditions pose significant computational challenges and remain largely unexplored experimentally.

To address this, we conducted the first hydrogen absorption experiments at stellar interior conditions at the National Ignition Facility, the only facility capable of reproducing such extreme states. We present a modeling approach avoiding costly hydrodynamic simulations and enabling rigorous uncertainty estimates of our measurement through Bayesian analysis.

P 15.6 Wed 17:30 ZHG102

Stereoscopic observations reveal coherent morphology and evolution of solar coronal loops — •B. Ram[1], L. P. Chitta[1], S. Mandal[1], H. Peter[1], and F. Plaschke[2] — [1]Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany — [2]Institut für Geophysik und extraterrestrische Physik, Technische Universität Braunschweig, Braunschweig, Germany

Coronal loops are bright, arched structures of magnetically confined, million-Kelvin plasma in the solar corona. The mechanisms responsible for heating these loops remain poorly understood. Investigation of the three-dimensional spatial morphology and temporal evolution of coronal loops will offer better insights into the underlying heating mechanisms. Some studies suggest that coronal loops may be optical illusions, resembling veils created by folds in two-dimensional sheets of plasma. Stereoscopic observations are, therefore, crucial to clarify their true morphology. We used high-resolution observations from the

Extreme Ultraviolet Imager (EUI) on the Solar Orbiter and the Atmospheric Imaging Assembly (AIA) on the Solar Dynamics Observatory to stereoscopically analyse coronal loops in an active region. Our analysis reveals that the loops exhibit nearly circular cross-sectional widths and consistent intensity variations along their lengths over a timescale of 30 minutes. These findings suggest that coronal loops are three-dimensional coherent plasma bundles that outline magnetic field lines indicating nanoflare heating rather than emissions caused by randomly aligned wrinkles in two-dimensional plasma sheets along the line of sight, as proposed by the 'coronal veil' hypothesis.