P 18: High Energy Density Physics III

Time: Thursday 16:15–17:30 Location: KH 01.020

Invited Talk P 18.1 Thu 16:15 KH 01.020

High-energy-density and high-pressure states investigated with x-ray imaging at HED-HiBEF — •Alejandro Laso Garcia — Helmholtz-Zentrum Dresden - Rossendorf, Dresden, Germany

The High Energy Density - Helmholtz International Beamline for Extreme Fields (HED-HiBEF) at the European XFEL combines the x-ray beam, with unparalleled spatial and temporal coherence and brilliance, with powerful optical drivers to probe and study extreme states of matter.

With the high-intensity short-pulse laser, ReLaX, reaching intensities of 10^{20} W/cm^2 on target, is used to isochorically heat matter and generate blastwaves in materials. It can also generate high-pressure states via cylindrical compression in micrometer-sized wires. Thanks to the narrow energy bandwidth of the XFEL beam, the energy can be tuned to be resonant with the transition energy between the K- and L- shell of specific charge states in the plasma.

The DiPOLE-100X, the high-energy nanosecond pulse duration laser is used to generate planar shocks in materials and study equation-of-state of highly compressed matter via shock compression.

All these experiments make use of the x-ray imaging platform developed at HED-HiBEF. In this talk we will provide a description of the platform and the spatial resolution achieved (better than 500 nm) as well as its application to all the cases mentioned above.

P 18.2 Thu 16:45 KH 01.020

A Megajoule Experiment at an XFEL: High-repetition Rate XRTS Measurements in Shock Compressed Plastics — •Thomas Gawne[1,2], Oliver S Humphries[3], Tobias Dornheim[2,1], and Thomas R Preston[3] — [1]CASUS, Görlitz, Germany — [2]HZDR, Dresden, Germany — [3]European XFEL, Schenefeld, Germany

The properties of plastics under laser compression are of broad importance due to their prevalence as ablators in shock-compression experiments and laser-driven inertial fusion energy schemes. Accurate measurements of their equation of state and electronic structure are therefore of paramount importance for predicting achievable conditions in laser-driven systems. Here we report on results from a recent experiment at the European XFEL, where the DiPOLE-100X laser was used to shock compress plastics at a repetition rate of 1 Hz with $\sim$30 J laser energy in 2ω. In the three day experiment, more than 34,000 laser shots were collected, and more than 1 MJ of laser energy fired at the targets. The systems were probed using simultaneous forward and backwards XRTS. Ultrahigh resolution measurements of the elastic feature in backscattering reveal the shock dynamics via the combined thermal Doppler broadening and shock-driven Doppler shift. Forward scattering measurements at multiple scattering angles show pronounced changes in the shape of the plasmon scattering between the different plastics, providing insights into the differences in their electronic properties and structures under shock compression. The setup and results presented here represent an important development for future laser compression experiments at XFEL facilities.

P 18.3 Thu 17:00 KH 01.020

Hydrodynamic equations for strongly coupled plasmas — •Daniels Krimans, Hanno Kählert, and Michael Bonitz — Institute of Theoretical Physics and Astrophysics, Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany

In strongly coupled plasmas, particle correlations dominate the dynamics, making theoretical descriptions challenging. To provide an alternative to computationally intensive particle-based methods, we present a hydrodynamic model obtained from the least action principle [1, 2]. In this approach, the pair distribution function is included directly into the Lagrangian, allowing correlation effects to be treated consistently while conserving energy and momentum.

We apply this framework to Coulomb [1] and Yukawa [2] one-component plasmas and analyze the linearized hydrodynamic equations by computing longitudinal and transverse modes. The obtained dispersion relations agree closely with molecular dynamics simulations over a wide range of coupling strengths and screening parameters, up to finite wavelengths comparable to the interparticle spacing.

We also outline how this variational framework may be extended to the quantum regime, thereby generalizing earlier formulations of quantum hydrodynamics [3] to strongly coupled systems. The resulting equations are expected to be relevant for inertial confinement fusion.

[1] D. Krimans and S. Putterman, Phys. Fluids **36**, 037131 (2024).
[2] D. Krimans and H. Kählert, arXiv:2506.23006v1 (2025).
[3] Zh. A. Moldabekov, M. Bonitz, and T. S. Ramazanov, Phys. Plasmas **25**, 031903 (2018).

P 18.4 Thu 17:15 KH 01.020

Matsubara Local Field Correction of Warm Dense Beryllium — •Maximilian Boehme[1], Tobias Dornheim[2], Jan Vorberger[2], and Zhandos Moldabekov[2] — [1]Lawrence Livermore National Laboratory — [2]Helmholtz-Zentrum Dresden-Rossendorf

Recent studies, including Dornheim et al. [EPL 147, 36001 (2024)], have highlighted the role of dynamical quantum effects encoded in the imaginary-time correlation function of the uniform electron gas in the warm dense matter (WDM) regime. In this work, we extend these efforts by employing the Fourier-Matsubara expansion framework introduced by Tolias et al. [J. Chem. Phys. 160, 181102 (2024)] to compute the Matsubara density-response function of warm dense beryllium using path-integral Monte Carlo simulations. We consider temperatures from 155.5 to 190 eV and densities between 7.5 and 30 g/cc, spanning a representative region of the WDM phase space. This approach provides access to electronic correlations and localization phenomena within the imaginary-time formalism. Furthermore, the resulting Matsubara density-response enables the extraction of the corresponding local field correction (LFC), thereby revealing the imaginary-frequency dependence of exchange-correlation effects in beryllium. Our results offer new insight into the microscopic dynamical behaviour of partially ionized systems and support the development of improved theoretical models for WDM.