P 11: Laser Plasmas

Time: Wednesday 11:00–12:15 Location: ZHG102

Invited Talk P 11.1 Wed 11:00 ZHG102

Ab initio path integral Monte Carlo simulation of warm dense matter — •Tobias Dornheim — Center for Advanced Systems Understanding (CASUS), Görlitz, Germany — Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Dresden, Germany

Understanding matter at extreme densities, temperatures and pressures is important for the modeling of astrophysical objects (e.g. giant planet interiors) and technological applications (most notably inertial confinement fusion) alike. Yet, the intricate interplay of effects such as Coulomb coupling, quantum degeneracy, and strong thermal excitations renders the rigorous theoretical description of such warm dense matter (WDM) challenging.

Here, I present an overview of a number of recent developments in the ab initio path integral Monte Carlo (PIMC) simulation of WDM. While being computationally demanding, PIMC is exact within the given error bars and, thus, constitutes a valuable benchmark for computationally more efficient but potentially less accurate methods such as density functional theory (DFT). Moreover, these simulations open up new avenues for the interpretation of X-ray Thomson scattering (XRTS) measurements, which is a key method of diagnostics for experiments with extreme states of matter. As a practical example, we consider a recent XRTS experiment on strongly compressed beryllium carried out at the National Ignition Facility (NIF) in Livermore, for which we find a significantly lower density based on both ab initio PIMC and DFT simulations compared to previously used chemical models and radiation hydrodynamics calculations.

P 11.2 Wed 11:30 ZHG102

Utilization of quasi-neutral plasma to enhance coherent light emission in free electron lasers — •Cagri Erciyes, Matteo Tamburini, and Christoph H. Keitel — Max Planck Institute for Nuclear Physics, Heidelberg

The behavior of relativistic quasi-neutral plasma and the corresponding enhancement of coherent light emission are investigated by examining the free electron laser (FEL) setup. A key characteristic of the lasing mechanism in FELs is microbunching, which leads to the concentration of beam charges into slices shorter than the radiation wavelength, thereby enhancing coherent radiation. We investigate microbunching and coherent emission in FELs when quasi-neutral beams (either electron/positron or electron/proton) rather than a pure-electron bunch are utilized. The possibility of denser beams is expected to lead to an enhancement of power gain via the microbunching mechanism. Due to the sensitivity of the lasing process to initial conditions, both Self-Amplified Spontaneous Emission (startup from shot noise) and seed laser mechanisms are explored.

P 11.3 Wed 11:45 ZHG102

The 40 mJ, kHz front-end and pre-amplifier of the KALDERA drive laser for plasma-acceleration — •Cora Braun[1,2], Caterina Vidoli[1], Juan B. Gonzalez-Diaz[1], Christian Werle[1], Timo Eichner[1], Thomas Hülsenbusch[1], Lutz Winkelmann[1], Guido Palmer[1], and Andreas R. Maier[1] — [1]Deutsches Elektronen Synchrotron DESY, Hamburg, Germany — [2]Institute for Experimental Physics, University of Hamburg, Hamburg, Germany

Scaling the repetition rate of laser-plasma accelerators from a few Hz towards the kHz range is a crucial step to enable future applications like free-electron lasers or direct synchrotron-injection. Moreover, a laser high-repetition rate enables active stabilization of crucial laser parameters which will support sub-percent energy spread and energy stability from the plasma accelerator. The KALDERA laser system at DESY will drive such a high repetition rate laser-plasma accelerator. The setup and commissioning of the first project phase, aiming for 100 Hz, 0.5 J, <30 fs pulses, is currently being completed. In this contribution the layout and performance of the in-house developed KALDERA kHz front-end and its subsequent cryogenic kHz-Ti:Sa pre-amplifier will be presented. We report on the performance of the individual subsystems and how they are interfaced to generate 40 mJ of pulse energy with sub-percent stability.

P 11.4 Wed 12:00 ZHG102

Towards studying the collective effects of laser driven ion acceleration. — •Erin G. Fitzpatrick, Laura D. Geulig, Maximlian J. Weiser, Runjia Guo, and Peter G. Thirolf — Ludwig-Maximilian-University

The ultra-high ion bunch density offered from laser-driven ion acceleration may affect the stopping behavior in matter via collective effects and ultimately enable to establish new nuclear reaction schemes like the 'fission-fusion' mechanism, aiming to generate extremely neutron-rich isotopes near N=126 [1]. One prerequisite needed for the realization of this mechanism is laser driven heavy ions with extremely high bunch densities(10^{22}-10^{23} cm^{-3})[1]. Experimental campaigns at different PW class lasers resulted in the acceleration of gold ions with bunch densities of about 10^{13} cm^{-3} (10^{16} cm^{-3}) at 1mm (100 μm) from the target [2]. At the Center for Advanced Laser Applications (CALA) we are working towards measuring collective effects in laser-driven ion bunches, like a potential reduction in stopping power. First experiments focused on proton bunch energy deposition in stopping materials downstream (0.1mm) from the ion source and demonstrated that we must consider shot-to-shot fluctuations of the ion bunch properties and damage caused to the stopping material through transmitted laser energy. An overview of the current results and developing experimental design is given.

[1] D. Habs et al., Appl. Phys. B 103, 471-484 (2011)
[2] F.H. Lindner et al., Sci. Rep. 12, 4784 (2022)