P 9: Theory of Quantum Plasmas II

Time: Tuesday 10:30–12:00 Location: SPA HS202

Invited Talk P 9.1 Tue 10:30 SPA HS202

FEL excited dense plasmas — •Beata Ziaja-Motyka — Center for Free-Electron Laser Science, DESY, Hamburg

In my talk I will give an overview on the recent results of our theoretical investigation how the unique properties of X-ray free-electron laser (FEL) radiation can be employed to create and investigate dense plasmas. I will discuss two topics that are related to various irradiation regimes that can be achieved, depending on the FEL pulse fluence and its wavelength: (i) modeling of nanoplasmas created from finite systems, and (ii) atomic processes within laser-created plasmas and warm-dense-matter.

P 9.2 Tue 11:00 SPA HS202

Large-Scale Simulations of Laser-Cluster Interactions — •Vikrant Saxena, Zoltan Jurek, Sang-Kil Son, Beata Ziaja, and Robin Santra — Centre for Free Electron Laser Science, Deutsches Elektronen-Synchrotron DESY, Notkestrasse 85, D-22607 Hamburg, Germany

Imaging of complex molecules and clusters, using soft and hard X-ray free electron laser (FEL) radiation is an area of frontline research. Computer simulations of irradiated objects have proven to be very helpful in understanding imaging experiments. In the present numerical approach, the nanoparticle dynamics is modeled using molecular dynamics code, XMDYN [Z. Jurek et al.] with inputs from the atomic physics code, XATOM [S.-K. Son et al.]. This approach has been very successful in simulating the interaction of femtosecond X-ray pulses with small clusters and molecules, containing $\lesssim 10^5$ atoms. Simulating large particles of $\gtrsim 10^6$ atoms, with a high degree of ionization, still remains a challenge, due to the $O(N^2)$ scaling of the computation time, N being the total number of atoms within the particle. In order to achieve a better scaling of computational efficiency with the particle size, we have recently implemented an improved BH-tree algorithm, into the XMDYN code, which brings the scaling down to $O(N\log N)$. The capability of the upgraded code, along with XATOM toolkit, to simulate the real time dynamics of large clusters triggered by ultrashort XFEL pulses, is demonstrated.

P 9.3 Tue 11:15 SPA HS202

Stochasticity effects in quantum radiation reaction — •Norman Neitz and Antonino Di Piazza — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

In the framework of classical electrodynamics radiation reaction effects were shown to decrease the energy spread of ion beams created by the collision of strong laser pulses with thin plasma foils [1]. However, by employing a kinetic approach [2] in the framework of strong-field QED [3] we demonstrate that quantum radiation reaction has the opposite tendency in the head-on collision of an electron beam with an intense laser pulse. We explain the broadening of the electron energy distribution with the intrinsic stochastic nature of photon emission which is substantial in the quantum regime [4]. Further, we study how the dynamics of the photons and charged particles is altered by the inclusion of the pair production process. Our numerical results indicate the feasibility of measuring the investigated effects with present technology.

[1] M. Tamburini et al., New. J. Phys. **12**, 123005 (2010).
[2] V. N. Baier, V. M. Katkov and V. M. Strakhovenko, "Electromagnetic processes at high energies in oriented single crystals" (World Scientific, Singapore, 1998).
[3] A. Di Piazza *et al.*, Rev. Mod. Phys. **84**, 1177 (2012).
[4] N. Neitz and A. Di Piazza, Phys. Rev. Lett. **111**, 054802 (2013).

P 9.4 Tue 11:30 SPA HS202

Implementation of QED effects in the PIC framework *PSC* — Constantin Klier, Hartmut Ruhl, Ben King, and •Fabian Deutschmann — Ludwig-Maximilians Universität München, 80539, Germany

The current and next generation (ELI) of laser facilities aim to generate peak intensities in the order of $10^{25} W/cm^2$ and higher, entering a regime where the quantum effects of radiation and pair production can no longer be neglected. It is therefore neccessary to incorporate these effects into simulations of the laser-plasma and seeded laser-vacuum interaction under such conditions.

Our group has created a numerical module for the Particle-In-Cell (PIC) framework *PSC* which is capable of modelling the dynamics of radiation friction, Compton scattering, and e^+e^- pair production. In the talk the theoretical foundations and present capabilities of our code will be presented and the numerical challenges will be discussed. In particular, an outline of our solution for an efficient, adaptive Monte-Carlo event-generator for the differential cross-sections needed in the code will be given.

P 9.5 Tue 11:45 SPA HS202

Electroweak Processes in Laser-Boosted Lepton Collisions — •Sarah J. Müller[1], Christoph H. Keitel[1], and Carsten Müller[1,2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf

Electroweak processes in high-energy lepton collisions are considered in a situation where the incident center-of-mass energy lies below the reaction threshold, but is boosted to the required level by subsequent laser acceleration. Within the framework of laser-dressed quantum field theory, we study the laser-boosted process $\ell^+\ell^- \to HZ^0$ in detail and specify the technical demands needed for its experimental realization. Further, we outline possible qualitative differences to field-free processes regarding the detection of the produced Higgs bosons.