P 4: Theory of Quantum Plasmas I

Time: Monday 14:00–15:15 Location: SPA HS202

Invited Talk P 4.1 Mon 14:00 SPA HS202

Collective modes of nonideal quantum systems in traps: from nanoplasmas to cold atoms — •Jan Willem Abraham and Michael Bonitz — Institut für theor. Physik und Astrophysik, CAU Kiel

We present a systematic approach to the theoretical description of the quantum breathing mode (QBM) – the radial expansion and contraction of a trapped system. In contrast to macroscopic systems, trapped systems are dominated by strong spatial inhomogeneity and finite size effects. While trapped classical particles are meanwhile well understood and accessible to first-principle computer simulations, their quantum counterparts still pose big challenges. In recent years numerous theoretical studies have demonstrated that the QBM is ideally suited to measure the coupling strength of a trapped system, its mean kinetic and interaction energy and other key observables [1]. In this talk, we show our results for trapped fermions and bosons with Coulomb and dipole interaction, respectively. We relate the breathing frequencies to the properties of the initial equilibrium system, giving rise to the application of the quantum mechanical sum rules. We demonstrate how an improved version of the conventional sum rule formulas is suitable for an accurate description of the QBM in one- and two-dimensional systems [2, 3].

[1] C.R. McDonald et al., Phys. Rev. Lett. **111**, 256801 (2013) [2] J.W. Abraham et al., New J. Phys. **16** 013001 (2014) [3] J.W. Abraham et al., Contrib. Plasma Phys., in press

P 4.2 Mon 14:30 SPA HS202

Structural dynamics of warm dense noble metals — •Fairoja Cheenicode Kabeer, Eeuwe S. Zijlstra, and Martin E. Garcia — Theoretical Physics, University of Kassel, Heinrich-Plett-Str. 40, 34132-Kassel, Germany.

The dynamical structural evolution of warm dense noble metals immediately following the intense extreme ultra-violet (XUV) optical excitations is important to understand the transition from warm dense matter to an ideal plasma state microscopically. In particular, so far, it is unknown, whether this transition occurs via thermal equilibration of hot electrons and cold atoms or nonthermally in the presence of hot electrons and cold atoms. Here we used density functional theory to compute the response of the phonon spectra of copper and silver in the presence of a core hole, with hot and cold electrons. We found that the average interatomic bonds become stronger in the warm dense state of both noble metals. The implications of this finding for the relaxation dynamics of warm dense matter to the plasma state are discussed.

P 4.3 Mon 14:45 SPA HS202

Quantum-statistical theory for plasma pressure broadening for H-like emitters — •Sonja Lorenzen — Institute of Physics, University of Rostock, D-18051 Rostock, Germany

To apply spectroscopy as a diagnostic tool for dense plasmas, a theoretical approach to pressure broadening is indispensable. Here, a quantum-statistical theory is used to calculate spectral line shapes of H and H-like Li. Ionic perturbers are treated quasi-statically as well as dynamically via frequency fluctuation model and model microfield method, see [1]. Electronic perturbers are treated in impact approximation. Strong electron emitter collisions are consistently taken into account with an effective two-particle T-matrix approach, see [2]. Convergent close coupling calculations give scattering amplitudes including Debye screening for neutral emitters. For charged emitters, the effect of plasma screening is estimated. Considered electron densities reach up to $n_e = 10^{27}$ m^{-3}. Temperatures are between $T = (10^4 - 10^5)$ K. Results for Lyman lines are compared with a dynamically screened Born approximation.

[1] Sonja Lorenzen, *Comparative study on ion-dynamics for broadening of Lyman lines in dense hydrogen plasmas*, Contributions to Plasma Physics, **53**, 368-374 (2013)

[2] Sonja Lorenzen, August Wierling, Heidi Reinholz, Gerd Röpke, Mark C. Zammit, Dmitry V. Fursa, and Igor Bray, *Quantum-statistical line shape calculation for Lyman-alpha lines in dense H plasmas*, J. Phys.:Conf. Ser., **397**, 012021 (2012)

P 4.4 Mon 15:00 SPA HS202

High-quality multi-GeV electron bunches via cyclotron autoresonance — •jianxing li[1], benjamin j. galow[1], yousef i. salamin[1,2], zoltán harman[1], and christoph h. keitel[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Department of Physics, American University of Sharjah, Sharjah, United Arab Emirates

Autoresonance laser acceleration of electrons is theoretically investigated using circularly polarized focused Gaussian pulses. Many-particle simulations demonstrate feasibility of creating over 10-GeV electron bunches of ultrahigh quality (relative energy spread of order 10^{-4}), suitable for fundamental high-energy particle physics research. The laser peak intensities and axial magnetic field strengths required are up to about 10^{18} W/cm^2 (peak power ∼10 PW) and 60 T, respectively. Gains exceeding 100 GeV are shown to be possible when weakly focused pulses from a 200-PW laser facility are used. In our parametric study of this acceleration scheme, substantial challenges still need to be dealt with, especially on the road to realizing experimentally the required high magnetic field strengths and laser powers.[1]

[1] B. J. Galow, J.-X. Li, Y. I. Salamin, Z. Harman, C. H. Keitel, Phys. Rev. ST Accel. Beams 16, 081302 (2013).