A 6: Correlation dynamics in plasmas and clusters II

Time: Monday 14:00–16:15 Location: V57.01

Invited Talk A 6.1 Mon 14:00 V57.01

Equilibration of Strongly Coupled Ultracold Plasmas — •Thomas Killian — Rice University, Houston, Texas, USA

Ultracold neutral plasmas provide a powerful platform for studying collisional equilibration in strongly coupled systems. They are created by photoionizing laser-cooled atoms at the ionization threshold, and the resulting ion and electron temperatures are orders of magnitude colder than in traditional neutral plasmas. The ions are strongly coupled and equilibrate with Coulomb coupling constant $1 < \Gamma_i < 4$. Because the density is relatively low compared to high-density strongly coupled plasmas, all relevant timescales are much longer, which provides great advantages for experiments.

The creation of the plasma involves a rapid hardening, or quench of the particle interactions. This leads to an exchange of potential and kinetic energy during subsequent thermalization called correlation induced heating. This is followed by oscillations of the kinetic energy at the ion plasma oscillation frequency. It is also possible to perturb the velocity distribution in an equilibrium plasma and observe the relaxation to a Maxwell-Boltzmann distribution. This allows a measurement of the collision rate in the strongly coupled regime, beyond the point where standard Landau-Spitzer theory becomes invalid. Both experiments probe general features of equilibrating strongly coupled systems and can be related to dynamics in other laser-produced plasmas.

Invited Talk A 6.2 Mon 14:30 V57.01

Short-Time Dynamics of Dust Clusters in Plasmas — •Andre Melzer[1], Tobias Miksch[1], Andre Schella[1], Jan Schablinski[2], Dietmar Block[2], and Alexander Piel[2] — [1]Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald — [2]IEAP, Christian-Albrechts-Universität Kiel

Dust clusters show a wide variety of fascinating dynamic properties which strongly depend on the exact particle number. For example, they can be heated from an ordered, solid state to a fluid state or perform normal mode oscillations. Moreover, magic number configurations show high structural and dynamical stability.

Dust clusters consist of a small number of microspheres (dust) trapped in a gaseous discharge plasma. There, the particles attain high negative charges due to the inflow of plasma electrons and ions.These dust clusters can be confined in 2D or 3D arrangements depending on the plasma conditions. They are ideally suited to measure the dynamical properties on the kinetic level of individual particles by (stereoscopic) video microscopy.

Here, we like to address the question of solid-liquid phase transitions in these finite systems in both 2D and 3D as well as their normal modes. These allow a detailed insight into the physical mechanisms of dust systems in particular and charged clusters in general.

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Invited Talk A 6.3 Mon 15:00 V57.01

Shell Formation Dynamics of a Spherical Yukawa Plasma — •Hanno Kählert[1,2] and Michael Bonitz[1] — [1]Christian-Albrechts-Universität zu Kiel — [2]Heinrich-Heine Universität Düsseldorf

Dusty plasmas allow for a fully kinetic investigation of various processes in strongly coupled plasmas—including their dynamics on short time scales. Here, we focus on the time-dependent correlation buildup in spherical dust clusters ('Yukawa Balls'). Starting from a laser-heated initial state, we investigate the time evolution of the dust cloud by Langevin dynamics simulations [1,2]. Due to friction with the neutral gas, the dust particles reach a strongly coupled state in the long-time limit with a well-defined radial shell structure [3]. For short and intermediate times, the simulations show that the cooling process is accompanied by a breathing oscillation of the plasma which manifests itself as a periodic modulation of the dust density. Special attention is paid to the influence of the screening parameter on the order of shell formation, and comparisons are made between closely related processes in ultracold neutral plasmas [4] and confined ion plasmas.

[1] H. Kählert and M. Bonitz, Phys. Rev. Lett. **104**, 015001 (2010)
[2] H. Kählert and M. Bonitz, Contrib. Plasma Phys. **51**, 519 (2011)
[3] M. Bonitz, C. Henning, and D. Block, Rep. Prog. Phys. **73**, 066501 (2010)
[4] T. Pohl, T. Pattard, and J. M. Rost, Phys. Rev. Lett. **92**, 155003 (2004)

A 6.4 Mon 15:30 V57.01

Plasma formation and ionization dynamics in laser-irradiated droplets — •Tatyana Liseykina and Dieter Bauer — Universität Rostock, Deutschland

We present our recent results on ionization dynamics and plasma formation in intense laser-droplet interaction using three-dimensional, relativistic PIC simulations with ionization included. The numerical simulations show that there exists a broad laser intensity regime for which wavelength-sized targets are not fully ionized. For higher-Z material this applies even to ultra-high intensities. Moreover, the results reveal that there exists an angle of incidence at which oscillating electric fields penetrate into the droplet, ionizing its interior. This leads to the formation of a highly asymmetric density distribution, concentrated mostly in the polarization plane, with the higher charge states not only within the skin layer on the surface but also around a focal point in the droplet interior.

A 6.5 Mon 15:45 V57.01

A collisional-radiative model for ns-pulsed laser ablation of metals — •David Autrique and Baerbel Rethfeld — TU Kaiserslautern, 67663 Kaiserslautern, Germany

Laser ablation is nowadays used in a growing number of applications, such as chemical analysis and pulsed laser deposition. Despite the many applications, the technique is still poorly understood. Therefore a model, describing the time dependent material evolution after short pulse laser irradiation, can be a helpful tool during the research quest. The transient behavior in and above a ns-laser irradiated copper target is modeled. Ultrafast phase transitions occur in the liquid, overheated layer. Subsequently a dense mixture of liquid and vapor is ejected above the target. Here a collisional-radiative model accounts for the laser-produced plasma kinetics. Stepwise collisional excitation, ionization, as well as photo processes result in plasma formation in the dense, expanding vapor plume. Calculated transmission profiles are compared with experimental results and similar trends are found.

A 6.6 Mon 16:00 V57.01

Multiscale Approach to Strongly Correlated Two-component Quantum Plasmas in Nonequilibrium — •Michael Bonitz[1], Patrick Ludwig[1], and James W. Dufty[2] — [1]Universität Kiel — [2]University of Florida

A key problem in the description of nonideal, multi-component plasmas is the drastic difference in the r,t-scales which prohibits first-principle simulations, in particular in nonequilibrium. We, therefore, develop a multiscale approach for dense quantum plasmas such as partially ionized Warm Dense Matter, where a full dynamic treatment of the pair correlations of the heavy particles is crucial. To this end the ions are treated exactly by classical Langevin Dynamcis simulations, whereas the electrons are treated fully quantum-mechanically on the basis of a quantum kinetic equation. The coupling of the two is performed in linear response and fully includes the dynamical screening of the ion-ion interaction on the basis of a nonequilibrium extension of the Mermin formula extending our recent results [1,2].

[1] P. Ludwig, M. Bonitz, H. Kählert, and J.W. Dufty, J. Phys. Conf. Series **220**, 012003 (2010) [2] P. Ludwig, H. Kählert, and M. Bonitz, submitted for publication in Plasma Physics and Controlled Fusion (2011)