P 18: Poster: Theorie/Simulation dichter und stark gekoppelter Plasmen

Zeit: Mittwoch 16:30–18:30 Raum: Foyer

P 18.1 Mi 16:30 Foyer

Induced inverse bremsstrahlung for dense plasmas in intense laser fields — Max Moll[1], Paul Hilse[1], Thomas Bornath[2], •Manfred Schlanges[1], and Vladimir P. Krainov[3] — [1]Institut für Physik, Universität Greifswald, Germany — [2]Institut für Physik, Universität Rostock, Germany — [3]Moscow Institute for Physics and Technology, Russia

During the interaction of matter with intense laser fields, plasmas with high density and high temperature are created. The heating of the plasma is significantly determined by inverse bremsstrahlung of the electrons due to electron-ion collisions. In this contribution we investigate the dependence of the heating rate on relevant parameters such as the mean ion charge, the laser field strength or the velocity of the electrons. Heating rates are calculated in first Born approximation as well as using a classical approach by solving Newton's equation. We study the influence of the inner ionic structure of noble gas ions (Ar, Kr, Xe) on the heating rates which can be achieved by the use of appropriate model potentials. Also considered are screening effects due to the surrounding plasma medium.

The dependence of the results on the kinetic energy of the electrons is discussed. The comparison with Coulomb-particles in the different approximations shows that it is important to account for the inner ionic structure.

P 18.2 Mi 16:30 Foyer

Quantum-statistical T-matrix approach to line broadening of hydrogen in dense plasmas — •Sonja Lorenzen[1], Yiling Chen[1], August Wierling[1], Heidi Reinholz[1,2], Gerd Röpke[1], Mark C. Zammit[3], Dmitry V. Fursa[3], and Igor Bray[3] — [1]Institute of Physics, University of Rostock, 18051 Rostock, Germany — [2]Institute for Theoretical Physics, Johannes Kepler University Linz, 4040 Linz, Austria — [3]Institute of Theoretical Physics, Curtin University of Technology, Perth WA 6845, Australia

Pressure broadening of spectral lines due to plasma electrons and ions can be used as a diagnostic tool to determine temperature and electron density of a dense plasma. Here, a quantum-statistical theory, based on thermodynamic Green's functions, is used to calculate hydrogen Lyman lines. The electronic self-energy Σ^{e} is an important input in this theory. It describes the influence of plasma electrons on bound state properties. In dense plasmas, the effect of strong, i.e. close, electron-emitter collisions can be considered by three-particle T-matrix diagrams. These diagrams are approximated with the help of an effective two-particle T-matrix, which is obtained from convergent close-coupling calculations with Debye screening, and results are compared with other theories.

P 18.3 Mi 16:30 Foyer

Time-dependent second Born calculations for model atoms and molecules in external fields — •Karsten Balzer, Sebastian Bauch, and Michael Bonitz — ITAP, Christian-Albrechts-Universität Kiel, Leibnizstr. 15, 24098 Kiel

Nonequilibrium Green function (NEGF) techniques attract more and more attention when correlated quantum many-particle dynamics is under investigation. Thereby, the solution of the Kadanoff-Baym equation (KBE) imposes strong challenges on the numerics—especially when applied to finite systems. This mainly affects the direct propagation of the KBE whereas obtaining equilibrium properties is conceptually relatively simple. Here, we extend previous work [1] to nonequilibrium and propagate the NEGF in the two-time domain. To render calculations possible, an efficient distributed memory algorithm has been developed enabling parallel and well-scalable computation of the NEGF. Also, the use of finite elements in combination with the discrete variable representation greatly simplifies summations over parts of Feynman diagrams. By comparing the density and the dipole moment to time-dependent Hartree-Fock results and the full solution of the time-dependent Schrödinger equation, we demonstrate that the time-dependent second Born approximation carries valuable information about correlation effects in atoms and molecules exposed to external fields [2]. As examples, we present results for helium, hydrogen and lithium hydride modeled in one spatial dimension. [1] K. Balzer, S. Bauch, and M. Bonitz, Phys. Rev. A **81**, 022510 (2010). [2] K. Balzer, S. Bauch, and M. Bonitz, Phys. Rev. A **82**, 033427 (2010).

P 18.4 Mi 16:30 Foyer

Dynamical Screening and Wake Effects in Streaming Classical and Quantum Plasmas — •Patrick Ludwig[1], Michael Bonitz[1], Hanno Kählert[1], and James Dufty[2] — [1]Christian-Albrechts Universität zu Kiel — [2]University of Florida, USA

In recent years we have shown that collective many-body properties in (i) complex (dusty) plasmas, and (ii) charge asymmetric quantum bilayers can be effectively tuned by changing the plasma parameters (temperature, density, mass-ratio of the different plasma constituents) or the effective range of the pair interaction (see [1] for an overview).

Here we significantly extend the previous analysis by inclusion of ion/electron drift by a high precision computation of the dynamically screened Coulomb potential from the dynamic dielectric function. This allows for an accurate description of all plasma properties including screening, wakefield oscillations, ion and electron thermal effects as well as collisional and Landau damping.[2]

The effective wake-potential results in attractive (non-reciprocal) forces between equally(!) charged plasma constituents, which leads to remarkable structural and dynamical many-particle features, which are well known in dusty plasmas. Similar effects are predicted for quantum plasmas.

[1] P. Ludwig, H. Thomsen, K. Balzer, A. Filinov, and M. Bonitz, Plasma Phys. Control. Fusion 52, 124013 (2010) [2] P. Ludwig, M. Bonitz, H. Kählert, and J.W. Dufty, J. Phys. Conf. Series 220, 012003 (2010)

P 18.5 Mi 16:30 Foyer

Correlation Effects and Phase Transitions in Mass-Asymmetric Electron-Hole Bilayers — •Jens Schleede[1], Alexey Filinov[2], Michael Bonitz[2], and Holger Fehske[1] — [1]Institute for Physics, Ernst-Moritz-Arndt Universität, Greifswald, Germany — [2]Institute for Theoretical Physics and Astrophysics, Christian-Albrechts-Universität, Kiel, Germany

We investigate the structural phase transition in two-dimensional mass-asymmetric electron-hole bilayer systems [1,2]. By using path integral Monte Carlo simulations, Coulomb correlations and quantum effects are treated on first princples. The bilayer systems show a variety of possible phases, e.g. exciton solid and gas, electron-hole liquid and hole crystal plus electron gas. For different layer separations, particle densities and temperatures we analyze the bond-angular and translational order correlation functions, the defect densities and the static structure factor. By means of these quantities we can determine the type of the phase transitions and whether there is an intermediate hexatic phase between the solid and the fluid phase. Furthermore the magnitude and phase of the complex angular bond-order parameter allows us to visualize the fragmentation of the solid into crystallite domains near the melting point [3].

[1] P. Ludwig *et al.*, Contrib. Plasma Phys. **47**, 335 (2007).
[2] S. De Palo *et al.*, Phys. Rev. Lett. **88**, 206401 (2002).
[3] P. Hartmann *et al.*, Phys. Rev. Lett. **105**, 115004 (2010).

P 18.6 Mi 16:30 Foyer

Crystallization of an exciton superfluid — Jens Böning, •Alexei Filinov, and Michael Bonitz — Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität, Leibnizstr. 15, D-24098 Kiel, Germany

Indirect excitons – pairs of electrons and holes spatially separated in semiconductor bilayers or quantum wells – are known to undergo Bose-Einstein condensation and to form a quantum fluid. Here we show that this superfluid may crystallize upon compression. However, further compression results in quantum melting back to a superfluid. This unusual behavior is explained by the effective interaction potential between indirect excitons which strongly deviates from a dipole potential at small distances due to many-particle and quantum effects [1]. Based on first principle path integral Monte Carlo simulations, we compute the complete phase diagram of this system and predict the relevant parameters necessary to experimentally observe exciton crystallization in semiconductor quantum wells.

[1] A Filinov, P Ludwig, M Bonitz, and Y E Lozovik, *J. Phys. A* **42**, 214016 (2009).

P 18.7 Mi 16:30 Foyer

Structural properties and collective excitations in 2D dipolar gas — •Alexey Filinov and Michael Bonitz — Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität, Leibnizstr. 15, D-24098 Kiel, Germany

We study properties of 2D bosonic gas interacting via dipolar potential. Using path integral Monte Carlo we investigate the equation of state, the density-temperature dependence of the superfluid density, the momentum distribution and the isothermal compressibility. We also evaluate the excitation spectrum, $\omega(\vec{k})$, of the longitudinal density oscillations in several approximations: classical QLCA [1], the density response evaluated using the Lindhard function, the sum-rules formalism [2], the analytical continuation from the imaginary time density correlation function using the stochastic optimization method [3].

From the obtained dispersion relations we analyze the formation in the spectrum of the roton minima and its connection with the normal density of the quasi-particles excitations using the Feynman formula.

[1] K. Golden, G. Kalman, Z. Donko and P. Hartmann, Phys. Rev. B **78**, 045304 (2008) [2] F. Dalfovo and S. Stringari, Phys. Rev. B **46**, 13991 (1992) [3] A. S. Mishchenko, Lect. Notes Phys. **739**, 367 (2008)

P 18.8 Mi 16:30 Foyer

Proton crystallization in a dense hydrogen plasma — •Michael Bonitz[1], Vladimir Filinov[2], Vladimir Fortov[2], Pavel Levashov[2], and Holger Fehske[3] — [1]Institut für Theoretische Physik und Astrophysik, CAU Kiel — [2]Institute for High Energy Density, Russian Academy of Sciences — [3]Institut für Physik, EMAU Greifswald

In a recent letter we have predicted that in a dense hydrogen plasma at sufficiently low temperatures protons would spontaneously order into a lattice which is embedded into an electron gas. The conditions for the stability of such an ion crystal in a neutral two-component plasma were derived in Ref. 1, in particular, we found that that a necessary condition for crystallization is that the mass of the heavy componenent exceeds the electron mass by a factor of about 80, so that effect should also be observable in various semiconductor materials [2].

Here we concentrate on the phase diagram of the proton crystal for which only a rough estimate is known. We present extensive first principle path integral Monte Carlo simulations which allow to predict the temperature and density range for proton crystallization in dense laboratory experiments.

[1] M. Bonitz, V.S. Filinov, V.E. Fortov, P.R. Levashov, and H. Fehske, Phys. Rev. Lett. 95, 235006 (2005)

[2] M. Bonitz, V.S. Filinov, V.E. Fortov. P.R. Levashov, and H. Fehske, J. Phys. A: Math. Gen. 39, 4717 (2006)

P 18.9 Mi 16:30 Foyer

Time propagation of the Nonequilibrium Green's function using the generalized Kadanoff-Baym ansatz — •Sebastian Hermanns, Karsten Balzer, and Michael Bonitz — ITAP, Christian-Albrechts-Universität Kiel, Leibnitzstr. 15, 24098 Kiel

For the description of many-particle systems the Green's function method has become widely used in the last decade. The equations of motion for this quantity are the Keldysh-Kadanoff-Baym equations (KKBE). The simplest approximation that includes correlation effects is the second Born approximation. However, as the two-time structure leads to quadratic scaling of the memory cost with simulation length, only short term dynamics can be computed. By introducing the generalized Kadanoff-Baym ansatz (GKBA) ansatz into the KKBE, the two-particle Green's function is reconstructed from its value on the time diagonal. This leads to a linear scaling of the memory cost with simulation length which makes longer time evolution possible.

In this contribution, we apply the GKBA to the time evolution of model atoms such as helium in one dimension [1,2]. With results for time dependent spatial and spectral properties the GKBA is compared to two-time 2nd Born-, Hartree-Fock-calculations as well as to the exact solution of the time-dependent Schrödinger equation. A special focus thereby lies on how well 2-electron excitations, which play an important role for the correlated electron dynamics, are represented in GKBA calculations.

[1,2] K. Balzer, S. Bauch, and M. Bonitz, Phys. Rev. A **81**, 022510 (2010) and **82**, 033427 (2010).

P 18.10 Mi 16:30 Foyer

Nonequilibrium Green's functions approach to the pair distribution function of quantum many-body systems out of equilibrium — •Kay Kobusch, Michael Bonitz, Karsten Balzer, and Lasse Rosenthal — Institut für Theoretische Physik und Astrophysik, Universität Kiel, D-24098 Germany

The pair distribution function (PDF) is a key quantity for analyzing correlation effects of a quantum system both in and far from equilibrium. We derive an expression for the PDF in terms of single particle Green's functions – the solutions of the Keldysh-Kadanoff-Baym equations in the two-time plane. The result includes initial correlations and generalizes previous density matrix expressions from single-time quantum kinetic theory. As an illustration we present numerical results for the PDF of electrons and holes in a strongly correlated electron-hole bilayer.

P 18.11 Mi 16:30 Foyer

Theoretical description of spherically confined strongly correlated Yukawa plasmas — Henning Bruhn[1], •Michael Bonitz[1], Jeff Wrighton[2], and James W. Dufty[2] — [1]Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität zu Kiel — [2]Department of Physics, University of Florida, Gainsville, Florida 32611, USA

A theoretical description for the radial density profile of strongly correlated identical charged particles confined in a harmonic trap is developed. A wide range of particle numbers and Coulomb coupling in the entire fluid phase is analyzed. The simple mean-field approximation is not capable to supply the shell structure observed in computer simulations and experiments due to the neglect of all correlations. The hypernetted chain approximation for the bulk fluid is used to extend the theory for confined charges. To achieve quantitative accuracy by comparison with Monte Carlo results a representation for the associated bridge function is found while restoring the form of the hypernetted chain equations.

P 18.12 Mi 16:30 Foyer

The Three Particle Correlation Function as a Tool for Angle Resolved Structural Analysis of Spherical Clusters — •Hauke Thomsen[1], Patrick Ludwig[1], Michael Bonitz[1], and Gabor Kalman[2] — [1]Christian-Albrechts Universität zu Kiel — [2]Boston College, USA

Finite charged particle ensembles in externally controlled confinement geometries allow for a systematic investigation of strong correlation effects over broad ranges of plasma parameters. Additionally, the formation of distinct shells emerges as a governing finite-size effect in systems of trapped ions and dusty plasma as well [1].

As a sensitve tool to study the internal cluster structure, we introduce the 'Three Particle Correlation Function' (TPCF), which allows for an angle resolved structure analysis.[2] The TPCF can not only resolve the transition probability of particles between shells, but also structural modifications within the shells. In particular this quantity is not affected by rotational invariance.

Using the TPCF we study the effect of Coulomb screening, temperature, and cluster symmetry of different ground and metastable states with respect to the exact particle number as well as the limiting case of large N.

[1] M. Bonitz, C. Henning, and D. Block, Reports on Progress in Physics 73, 066501 (2010) [2] P. Ludwig, H. Thomsen, K. Balzer, A. Filinov, and M. Bonitz, Plasma Phys. Control. Fusion 52, 124013 (2010)

P 18.13 Mi 16:30 Foyer

Modeling Laser Manipulation of 2D Yukawa Clusters — •Hauke Thomsen, Hanno Kählert, and Michael Bonitz — Christian-Albrechts Universität zu Kiel

The ability to influence the spatial structure and the velocity distribution of two-dimensional trapped Yukawa clusters by lasers has been exploited in different experiments in order to analyze melting effects[1,2]. We present results of Langevin Molecular Dynamic simulations which allow to model these processes in detail.

The goal is to get a better understanding of how the additional time dependent force affects on the particles dynamics. Not only the absolute laser power is important for the cluster manipulation, but also the scanned pattern plays a mayor role as well the scanning speed. Depending on the scanning parameters the laser can either cause heating or provide a quasi-static force field. Often, even small changes in the simulation parameters result in major changes in the clusters' behavior.

[1] M. Wolter and A. Melzer, Phys. Rev. E 71, 036414 (2005)

[2] J. Schablinski, Kontrolle von Struktur und Dynamik finiter Plasmakristalle mittels Lasermanipulation, Diplomarbeit, CAU Kiel (2010)

P 18.14 Mi 16:30 Foyer

Collective excitations of a spherically confined Yukawa plasma — •Hanno Kählert and Michael Bonitz — ITAP, Christian-Albrechts Universität zu Kiel

We compare the results of a recently developed fluid theory for the multipole modes of a Yukawa plasma in a spherical confinement [1] with molecular dynamics (MD) simulations [2]. The simulations confirm the existence of high order modes found in cold fluid theory. The eigenfrequencies are in close agreement with the theory for weak to moderate screening and low order modes. We discuss the influence of screening, coupling and friction on the mode spectra. Further, we examine the relations between the breathing mode in the fluid theory, the MD simulation and the respective crystal eigenmode in more detail.

[1] H. Kählert and M. Bonitz, Phys. Rev. E **82**, 036407 (2010)
[2] H. Kählert and M. Bonitz, arXiv:1011.5849 (2010)

P 18.15 Mi 16:30 Foyer

Laserunterstützte Anregungen in finiten Yukawa-Systemen — •André Schella, Carsten Killer, Tobias Miksch und André Melzer — Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald, 17489 Greifswald

Eine Ansammlung von wenigen Staubteilchen in einem dreidimensionalen externen Einfangpotential innerhalb einer Plasmaumgebung bezeichnet man als Yukawa-Ball. Grund hierfür ist die Yukawa-Wechselwirkung zwischen den einzelnen Partikeln. Solche in HF-Entladungen eingefangene Yukawa-Bälle stellen einen idealen Forschungsgegenstand dar, wenn es um die Untersuchung dynamischer Eigenschaften von Systemen mit endlicher Teilchenzahl geht. Die Bewegung der einzelnen Partikel lässt sich mit Hilfe eines Stereoskopiesystems individuell und auf kinetischer Ebene verfolgen. Vorgestellt werden Ergebnisse, die den Einfluss einer Manipulation von Staubclustern mithilfe von Lasern sowohl auf individuelle Partikel als auch den Cluster als Ganzes zeigen. Die Normalmodenanalyse, also die Zerlegung der Teilchenbewegung in kollektive Schwingungsmuster, bietet einen Zugang zur experimentellen Untersuchung der dynamischen Eigenschaften dieser finiten, stark gekoppelten Systeme. Die Laserheizung bewirkt eine Änderung in der Modenstruktur, die sich im Leistungsspektrum der einzelnen Cluster bemerkbar macht. Diese Arbeit wird gefördert vom SFB TR 24, Teilprojekt A3.

P 18.16 Mi 16:30 Foyer

Nichtlineare Eigenschaften von selbsterregten Staubdichtewellen — •Tim Bockwoldt, Kristoffer Ole Menzel, Oliver Arp und Alexander Piel — IEAP, CAU-Kiel, D-24098 Kiel

Im staubigen Plasma einer HF-Entladung entstehen bei niedrigen Neutralgasdrücken und ausreichend hohen Staubdichten selbsterregte Staubdichtewellen. Diese besitzen einen stark nichtlinearen Charakter. In Wellenfeldern unter Schwerelosigkeit wurde kürzliche die Bildung von Frequenzclustern beobachtet. Dabei traten an den Clustergrenzen sogenannte Defekte als Bifurkationen in Wellenfronten auf [1]. Desweiteren zeigten Messungen eine Wechselwirkung der Staubdichtewellen mit dem Plasma [2]. In diesem Beitrag werden Ergebnisse aus komplementären Experimenten im Labor und aus zusätzlichen Messungen unter Schwerelosigkeit vorgestellt, die eine detailliertere Analyse der beobachteten Effekte zulassen. Es wurde gefunden, dass die Dichte der Defekte mit der HF-Spannung steigt. Mit steigender Defektdichte nimmt die Kohärenz im Wellenfeld ab. Dies spiegelt sich auch durch Veränderungen der räumlichen Frequenzverteilung wider. Die Messungen zur Wechselwirkung zwischen Staub und Plasma konnten durch eine verbesserte Diagnostik erweitert werden. Neben einer Modulation des Plasmaleuchtens innerhalb des Wellenfeldes konnte auch im staubfreien Bereich (Void) eine Modulation gemessen werden. Gefördert durch DLR unter 50WM0739.

[1] K. O. Menzel, O. Arp, und A. Piel, Phys. Rev. Lett. 104, 235002 (2010).
[2] O. Arp et al., IEEE Transactions on Plasma Sci. 38, 842 (2010).

P 18.17 Mi 16:30 Foyer

Schmelzverhalten finiter Plasmakristalle — •Jan Schablinski, Dietmar Block und Alexander Piel — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel

Phasenübergänge stark gekoppelter zweidimensionaler Systeme wurden viele Jahre intensiv anhand ausgedehnter Systeme untersucht und sind für diesen Fall bereits gut verstanden. Sowohl theoretisch als auch experimentell konnte jedoch gezeigt werden, dass Struktur und Stabilität in finiten Systemen stark von der Teilchenzahl und Symmetrien der Teilchenanordnung abhängen. Eine nach wie vor offene Frage ist, ob und wie sich strukturelle Unterschiede solcher Cluster auch auf deren Schmelzverhalten auswirken. Bislang fehlten geeignete Methoden, um die kritische Temperatur finiter Kristalle zuverlässig zu bestimmen. Hierzu wurde die Methode der Varianz der block-gemittelten Interpartikelabstandsfluktuationen (VIDF) als sensitiver Parameter für einen Phasenübergang vorgeschlagen [1]. Dieser Beitrag stellt Experimente vor, mit denen diese Methode an realen Plasmakristallen erprobt wird. Hierbei findet die Lasermanipulation unter anderem in Form eines stochastischen Heizprozesses Anwendung, um die (kinetische) Temperatur des Partikelsystems kontrolliert zu manipulieren. Die angewandte Heizmethode ist für die Untersuchung von finiten Plasmakristallen optimiert und wird in Hinblick auf die Isotropie der Heizung sowie die resultierende Partikeldynamik im Detail analysiert. Darüber hinaus wird der Zusammenhang zwischen Symmetrien und Struktur und der Schmelztemperatur finiter Plasmakristalle systematisch untersucht.

[1] Böning et al., PRL 100, 2008

P 18.18 Mi 16:30 Foyer

Nonlinear magnetoplasmons in strongly coupled Yukawa and Coulomb plasmas — •Torben Ott[1], Michael Bonitz[1], Zoltan Donkó[2], and Peter Hartmann[2] — [1]Christian-Albrechts-Universität Kiel, Institut für Theoretische Physik und Astrophysik — [2]Research Institute for Solid State Physics and Optics, Hungarian Academy of Sciences, Budapest

The wave spectra of magnetized and strongly coupled 2D-Yukawa plasmas have recently been computed numerically [1] and good agreement between existing theories and the simulation was found. The magnetized Yukawa plasma sustains two modes, the magnetoplasmon and the magnetophonon, the frequencies of which are of the order of the Einstein or cyclotron frequency.

In this contribution, we report on the existence of additional high-frequency plasma oscillations at multiples of the magnetoplasmon, based on extensive molecular dynamics simulations. The emergent modes are reminiscent of the well-known Bernstein modes but are renormalized by the strong interparticle correlations. We present detailed numerical results and an analytical explanation of the observed features [2].

[1] Hou *et al.*, Phys. Plas., **16**, 73704 (2009)
[2] Bonitz *et al.*, Phys. Rev. Lett., **105**, 055002 (2010)

P 18.19 Mi 16:30 Foyer

Pair Correlations for Charges in a Harmonic Trap — Jeffrey Wrighton[1], James Dufty[1], •Hanno Kählert[2], Torben Ott[2], Patrick Ludwig[2], and Michael Bonitz[2] — [1]Physics Department, University of Florida — [2]Institut für Theoretische Physik und Astrophysik*Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität zu Kiel

A classical system of N identical charges in a harmonic trap exhibits both shell structure and orientational ordering due to Coulomb correlations. The shell structure can be reproduced accurately using approximate correlations from the bulk OCP [1]. Here we report additional relationships between correlations in the trap and those for the bulk OCP: 1) pair correlations calculated without reference to their location in the trap agree with those of the bulk OCP. 2) orientational pair correlations among particles within a shell are represented by those of the bulk OCP, when Euclidean distance is replaced by arc length (qualitative agreement using 3D OCP; quantitative agreement using 2D OCP). At stronger coupling, the correlations induce an ordering within the shells (spherical Wigner crystal). It is shown that the orientational correlations for this phase are described by thos for the single sphere Thomson problem, i.e. the Thomson sites represent the "lattice" for the spherical crystal. Finite temperature effects for this phase are described as well. (Research supported by DOE award DE-FG02-07ER54946 and by the Deutsche Forschungsgemeinschaft via SFB-TR24.)

[1] J. Wrighton, J. Dufty, H. Kählert, and M. Bonitz, Phys. Rev. E 80, 038912 (2009), Contrib. Plasma Phys. 50, 26 (2010)

P 18.20 Mi 16:30 Foyer

Quantum breathing mode of interacting particles in a harmonic trap — •Jan Willem Abraham, Karsten Balzer, Sebastian Bauch, and Michael Bonitz — ITAP, Christian-Albrechts-Universität Kiel, Leibnizstr. 15, 24098 Kiel

Time-dependent properties of interacting, harmonically confined quantum systems are of growing interest in many areas, including correlated electrons in metal clusters or quantum dots and ultracold Bose and Fermi gases in traps or optical lattices. Among these properties the behavior of the breathing mode (BM)—the [uniform] radial expansion and contraction of the system—attracts special interest as it is easily excited experimentally, and turns out [1] to give information of the system's dimensionality, spin statistics, as well as the form and strength of the pair interaction potential.

Extending our previous work [1,2], we deepen the understanding of the BM during migration from the ideal quantum to the classical regime, in between which the breathing frequency is not independent of the pair interaction strength. Thereby, time-dependent Hartree-Fock simulations for 2 to 15 fermions with Coulomb interaction are expected to answer the question whether the quantum BM is independent of particle number [3].

[1] S. Bauch, K. Balzer, C. Henning and M. Bonitz, Phys. Rev. B **80**, 054515 (2009). [2] S. Bauch, D. Hochstuhl, K. Balzer and M. Bonitz, J. Phys. Conf. Series **220**, 012013 (2010). [3] J.W. Abraham, Bachelor thesis, Kiel University, 2010.

P 18.21 Mi 16:30 Foyer

Configuration path integral Monte Carlo simulation of correlated fermions — •Tim Schoof[1], Alexej Filinov[1], Michael Bonitz[1], and James W. Dufty[2] — [1]Institut für Theoretische Physik und Astrophysik, Leibnitzstraße 15, 24098 Kiel — [2]Physics Department, University of Florida, Gainesville

We develop a new path integral Monte Carlo approach which is formulated in occupation number representation. The method is applied to strongly correlated fermions in a trap [1]. Formally exact results are obtained by a transition from discrete to continuous imaginary time representation [2]. The efficiency of the method (fermion sign problem) is investigated for a broad range of temperatures, coupling parameters and particle numbers and compared to standard path integral Monte Carlo methods.

[1] T. Schoof, A. Filinov, M. Bonitz and J.W. Dufty to be published

[2] N. V. Prokof'ev, B. V. Svistunov, and I. S. Tupitsyn, JETP Lett. 64, 911 (1996)

P 18.22 Mi 16:30 Foyer

Ionization and electron scattering on ions in strong electromagnetic fields — •Christopher Hinz, Sebastian Bauch, and Michael Bonitz — Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität zu Kiel, Leibnizstraße 15, D-24098 Kiel

The field of time-resolved measurements on ultrashort timescales has evolved rapidly in recent years[1] giving access to the complex electron dynamics in strong external fields. Among those, one fundamental process is electron-ion scattering in the presence of strong electromagnetic fields, leading to distributions of high-energy electrons[2]. Extending previous work on wave-packet scattering on fixed geometries of single ions and ion chains[3], which leads to significant increase in electron energies due to resonance effects, we present results for combinations of ions and atoms in a pump-probe setup. Here, one atom serves as an electron source through XUV excitation and the following IR induced acceleration leads to scattering on the parent ion as well as on neighbouring ions. The influence of several system parameters, such as pulse parameters, delay between both pulses and scattering geometries, is investigated by means of numerical solutions of the time-dependent Schrödinger equation. Physical insight is motivated by simple semiclassical estimations.

[1] see e.g. F. Krausz and M. Ivanov, *Rev. Mod. Phys.*, **81** 163 (2009);
[2] H.-J.Kull, and V. T. Tikhonchuk, Phys. Plas. **12** 063301 (2005);
[3] S. Bauch and M. Bonitz,*Contrib. Plas. Phys.* **49** 558 (2009)

P 18.23 Mi 16:30 Foyer

Electronic correlations in double ionization of atoms in pump-probe experiments — •Sebastian Bauch, Karsten Balzer, and Michael Bonitz — Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität zu Kiel, D-24098 Kiel

The (correlated) dynamics of few-body systems in strong laser fields is in focus of active research since the last two decades. One example is the famous non-sequential double ionization of Helium. With nowadays experimentally available tools it is possible to investigate these processes on the sub-femtosecond timescale. Typically, a short extreme ultraviolet (XUV) pump pulse is combined with a longer infrared (IR) probe pulse. We present theoretical results based on the time-dependent Schrödinger equation for such a pump-probe experiment involving two active electrons[1]. A dramatic change of the double-ionization yield with variation of the pump-probe delay is reported. We identify the governing role of electron-electron correlations, through a complex interplay of (1) inner-atomic electron shake up and (2) rescattering with subsequent impact ionization. Our results allow for a direct control of the double ionization yield, and the relative strength of double and single ionization.

[1] S. Bauch, K. Balzer and M. Bonitz, *Europhys. Lett.* **91** 53001 (2010)

P 18.24 Mi 16:30 Foyer

Laser-assisted photoemission: the case of low-frequency streaking. — •Sebastian Bauch and Michael Bonitz — Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität zu Kiel, D-24098 Kiel

Laser-assisted photoemission has attracted growing attention in the last decade. Two main fields of ongoing experimental effort exist, the fundamental investigation of ultrafast processes and the application to pulse characterization of currently developed light sources, e.g. free-electron lasers. Both utilize realizations of the light-field induced streak camera, but in different temporal regimes. Adopting well-established methods, we extend previous investigations[1] to the currently evolving experimental situation[2] and present line shapes from laser-assisted photoemission ranging from the well-investigated case of infrared streaking to the widely unexplored low-frequency case of terahertz radiation. Exact solutions of the time-dependent Schrödinger equation are compared to approximate (simple) models. Various effects, including Coulomb effects, wave packet polarization and nucleus effects are addressed.

[1]e.g. O. Smirnova, M. Spanner and M. Ivanov, *J. Phys. B. At. Mol. Opt. Phys.* **39** S323 (2006)

[2]U. Frühling et al., *Nat. Phot.* **3** 523 (2009)

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Energy Transfer in Relativistic Laser Plasmas — •Marco Swantusch[1], Mirela Cerchez[1], Monika Toncian[1], Christian Rödel[2], Oliver Jäckel[2], Toma Toncian[1], Alexander A. Andreev[3,4], Gerhard G. Paulus[2], and Oswald Willi[1] — [1]Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf, Germany — [2]Institut für Optik und Quantenelektronik, Friedrich-Schiller-Universität Jena, Germany — [3]Max Born Institut, Berlin, Germany — [4]Vavilov State Optical Institute, Sankt Petersburg, Russia

The interaction of nowadays routinely generated intense, ultra-short laser pulses with solid targets can create states of matter characterized by very high temperatures and densities close to solid. We present the results of recently finished experiments dealing with the absorption of laser energy in the ultrashort (<30 fs), high intensity ($I \approx 5 \times 10^{19}\ W/cm^2$) regime. The influence of different parameters (laser contrast, angle of incidence, surface quality, e.g.) has been studied. It is experimentally proven that the energy transfer is strongly dependent on these quantities.

Combined simulations using hydrodynamic and two dimensional Particle-In-Cell codes have been performed in order to investigate the influence of the plasma scale length to the absorption process and are in good agreement with the experimental data. Furthermore, an analytical model is proposed to explain the complex interconnections between absorption mechanism, laser and target parameters.

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Plasma diagnostics applying K-line emission profiles of mid-Z materials — Kristine Karstens, •Yiling Chen, and Andrea Sengebusch — Universität Rostock, Institut für Physik, Rostock

In recent years K-line spectra have become the focus of various experiments. Narrow K-line emission of some keV is an appropriate light scource for Thomson scattering on warm dense matter with solid and even over-solid electron density. Moreover, as the K-spectra are often emitted from a warm dense plasma themselves one can infer plasma parameters, i.e. temperature, density and composition, by studying the line profiles [1,2]. Theoretical treatment of spectral line profiles using a self-consistent ion sphere model is applied on moderately ionized mid-Z materials. A consistent extension of the Planck-Larkin renormalization to these elements is shown. In this poster we focus on the influence of plasma polarization effects on the K-line emission energy and satellite transitions due to M-shell ionization and excitation. It is shown that important contributions to the line profiles are due to excited radiator states [3].

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X-ray scattering as diagnostic tool for mixtures in warm dense matter — •Kathrin Wünsch[1], Jan Vorberger[1], Dave A. Chapman[1,2], and Dirk O. Gericke[1] — [1]Centre for Fusion, Space and Astrophysics, Department of Physics, University of Warwick, Coventry CV4 7AL, United Kingdom — [2]Plasma Physics Department, AWE plc. Aldermaston, Reading, Berkshire, United Kingdom

A deeper understanding of warm dense matter (WDM) is of particular interest, not only in the research of astrophysical objects, but also in the progress towards inertial confinement fusion.

The development of powerful lasers makes it possible to study WDM in the laboratory. X-ray scattering has become an effective diagnostic tool to determine basic plasma parameters as well as structural information. A complete diagnostics does however rely on an excellent theoretical understanding of the material under consideration. Recently, attention was brought to multicomponent WDM where the interplay of different ions species gives rise to new features.

We developed a consistent model to analyse the scattering spectra including multicomponent effects. Therefore, we generalised the Chihara formula and determine all the cross correlations required. The results will show that x-ray scattering can also be used to investigate mixtures under extreme conditions due to significant differences of the multicomponent description to a single-ion component approach. Furthermore, we will present results how the scattering spectra will change if non-equilibrium distributions are applied.