Symposium Strongly coupled plasmas (SYCP)

gemeinsam veranstaltet von den Fachverbänden
Plasmaphysik
Atomphysik
Quantenoptik

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Stark gekoppelte Plasmen haben sich in den letzten Jahren zu einem vielfältigen, breitgefächerten Gebiet entwickelt. In diesem Symposium werden übergreifende Fragestellungen aus den Bereichen Plasmaphysik, Atomphysik und Quantenoptik diskutiert und Fortschritte in diesem hochaktuellen Gebiet dargestellt.

Übersicht der Hauptvorträge und Fachsitzungen

(Hörsaal 5D)

Hauptvorträge

SYCP 1.1	Di	14:00–14:30	5D	**Ultracold Neutral Plasmas** — •Steven Rolston
SYCP 1.2	Di	14:30–15:00	5D	**Collisional absorption of intense laser fields in dense plasmas** — •Manfred Schlanges, Thomas Bornath, Paul Hilse
SYCP 1.3	Di	15:00–15:30	5D	**At the frontier of cold Rydberg gases and ultracold plasmas** — •Pierre Pillet
SYCP 1.4	Di	15:30–16:00	5D	**Complex Plasmas: New Discoveries in Strong Coupling Physics** — •Gregor Morfill
SYCP 1.5	Di	16:30–17:00	5D	**Three-dimensional long-range ordered structures in RF confined ion Coulomb crystals** — •Michael Drewsen
SYCP 1.6	Di	17:00–17:30	5D	**Forming, trapping, and cooling of strongly magnetized highly excited antihydrogen atoms** — •Hossein Sadeghpour
SYCP 1.7	Di	17:30–18:00	5D	**Ionization dynamics of clusters in strong laser fields** — •Karl-Heinz Meiwes-Broer, Tilo Döppner, Thomas Fennel, Johannes Passig, Josef Tiggesbäumker
SYCP 1.8	Di	18:00–18:30	5D	**Initiation of ultracold plasma formation by long-range forces between Rydberg atoms** — •Thomas Amthor, Markus Reetz-Lamour, Janne Denskat, Matthias Weidemüller

SYCP 1: Symposium Strongly Coupled Plasmas

Zeit: Dienstag 14:00–18:30 Raum: 5D

Hauptvortrag SYCP 1.1 Di 14:00 5D

Ultracold Neutral Plasmas — •Steven Rolston — University of Maryland, College Park, MD, USA

Ultracold neutral plasmas, formed by photoionizing laser-cooled samples of atoms, show some evidence of strong coupling in the ions, although the electrons do not appear to be strongly coupled, at least at early times in the expansion (the UCPs are unconfined). The long-time temperature evolution is as yet unmeasured, and copious Rydberg atom formation at late times and low densities brings into question whether the electron temperature may be much lower than at early times. I will discuss measurements of three-body recombination and Rydberg atom formation using microwave ionization of the Rydberg atoms as a detection mechanism. The dynamics of such UCPs is dominated by the expansion, and any modifaction may have signficant effects of the plasma. I will also discuss our current efforts to confine UCPs with magnetic fields, and the observation of plasma instabilities observed in the course of this research.

Hauptvortrag SYCP 1.2 Di 14:30 5D

Collisional absorption of intense laser fields in dense plasmas — •Manfred Schlanges[1], Thomas Bornath[2], and Paul Hilse[1] — [1]Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald, 17487 Greifswald — [2]Institut für Physik, Universität Rostock, 18051 Rostock

In the last years, laser-matter interaction has become a field of increasing interest. This is due to the impressive progress in laser technology which makes it possible to create dense non-equillibrium plasmas by high intensity femtosecond laser pulses. Of special importance for modelling intense laser-matter interaction is to understand the transfer processes of energy from the laser field to matter. If solid targets or clusters are irradiated by intense laser pulses, dense two-temperature plasmas are created. Important mechanisms of energy deposition are ionization processes as well as collisional absorption. In a first part of this contribution, collisional absorption of dense plasmas in strong laser fields is investigated in the framework of quantum kinetic theory. An important quantity is the electron–ion collision frequency. For the latter, quantum statistical expressions are derived. Numerical results are presented for dense hydrogen and aluminium plasmas. Furthermore, we compare with molecular dynamics simulations. Finally, an application is given to describe finite systems like nanoplasmas in large argon and silver clusters interacting with intense laser pulses.

This work was performed under the auspices of the SFB 652 "Strong correlations and collective phenomena in radiation fields: Coulomb systems, clusters and particles".

Hauptvortrag SYCP 1.3 Di 15:00 5D

At the frontier of cold Rydberg gases and ultracold plasmas — •Pierre Pillet — Laboratoire Aimé Cotton, CNRS, Bât.505, Campus d'Orsay, 91405 Orsay cedex, France

Cold Rydberg atomic samples are fascinating because they are at the frontier of atomic, solid state and plasma physics. A first example is the limitation of the Rydberg excitation due to long-range dipole-dipole interactions between Rydberg atoms with the so-called dipole blockade effect observed by adding an electric field or at a Förster resonance. An exciting possible application is the realization of scalable quantum gates. A second example is given by a dense ensemble of cold Rydberg atoms which can evolve towards an ultracold plasma. The mechanism of the formation of the ultracold plasma will be discussed. It is complex, first initiated by different ionization elementary processes. In this first phase, the dipole forces between Rydberg atoms play a role for Penning ionization. When the ionic space charge becomes important enough to trap the electrons, these electrons ionize then rapidly all the Rydberg atoms in an avalanche process, leading to the formation of a quasi-neutral plasma. Different processes as superelastic collisions, electronic recombinations need to be considered in this second phase for a complete understanding. To reach the regime where the Coulomb interctions between the plasma particules become important compared to their kinetic energy will lead to strong spatial correlations up to the crystallization. Cooling such an ultracold plasma is therefore an important challenge. The idea of adding Rydberg atoms to an ultracold plasma to control its electronic temperature has been investigated.

Hauptvortrag SYCP 1.4 Di 15:30 5D

Complex Plasmas: New Discoveries in Strong Coupling Physics — •Gregor Morfill — Max-Planck-Institut fuer extraterrestrische Physik, Garching

The talk focuses on new developments in strong coupling physics, based on experiments and theory in complex plasmas. Making use of the unique properties of complex plasmas-the ability to visualise the systems at the individual particle level, the excellent time resolution at the relevant interaction time scales and the ease of manipulation- a number of fundamental generic issues can be investigated at the most elementary (individual particle) level: the stability principles of condensed matter, the onset of cooperative phenomena, pathways to equilibrium, laminar shear flows, kinetic onset of turbulence, self-organising principles in crystal growth. We will discuss the latest progress in some of these areas.

30 mins break

Hauptvortrag SYCP 1.5 Di 16:30 5D

Three-dimensional long-range ordered structures in RF confined ion Coulomb crystals — •Michael Drewsen — Institute of Physics and Astronomy, University of Aarhus, DK-8000 Aarhus C, Denmark

When an ensemble of trapped ions is cooled below a certain critical temperature it forms a very sparse and fragile type of solid, often referred to as a Coulomb crystal. The spatially ordered structures of such solids depend critically on the actual trapping fields as well as on the number of the trapped ion species. Recently, we have observed three-dimensional long-range ordered structures in near-spherically symmetric single-species Coulomb crystals of $^{40}Ca^{+}$ ions confined in a linear rf Paul trap. The long-range ordered structures appeared as soon as the number of ions exceeded $\sim$1000 ions. Though this result is unexpected from molecular dynamics (MD) simulations of the systems ground states, it is found to be in agreement with MD simulations of metastable ion configurations. We have as well observed three-dimensional long-range ordered structures in the central $^{40}Ca^{+}$ ion component of $^{40}Ca^{+}$-$^{44}Ca^{+}$ two-species ion Coulomb crystals in a linear Paul trap. The structures here are strikingly more persistent (lifetimes of 10 s) and always of one specific type in one particular orientation. Molecular dynamics simulations strongly indicate that these characteristics are a consequence of an effective anisotropy in the inter-ion interaction induced by the radio frequency quadrupole trapping field.

Hauptvortrag SYCP 1.6 Di 17:00 5D

Forming, trapping, and cooling of strongly magnetized highly excited antihydrogen atoms — •Hossein Sadeghpour — Harvard-Smithsonian Center for Astrophysics, Cambridge, Ma USA

A theoretical framework for the formation of Rydberg atoms in strong magnetized nonneutral plasma will be described with an aim toward the production of highly excited Rydberg antihydrogen ($\bar{H}$) atoms at CERN. A number of challenges hindering a quantitative understanding of how Hbar atoms are formed- the details of velocity and field ionization spectra- are overcome. It is shown that a novel cooling technique due to spontaneous decay efficiently brings the Rydberg $\bar{H}$ atoms to their ground state and leads to trapping of ground state $\bar{H}$ atoms. The long-time dynamics in strong inhomogeneous magnetic field traps is numerically investigated and analytical expressions for the cooling efficiency and final temperature as a function of the trapping magnetic multipole order will be given.

Hauptvortrag SYCP 1.7 Di 17:30 5D

Ionization dynamics of clusters in strong laser fields — •Karl-Heinz Meiwes-Broer, Tilo Döppner, Thomas Fennel, Johannes Passig, and Josef Tiggesbäumker — University of Rostock, Institute of physics, Universitätsplatz 3, 18051 Rostock

Atomic clusters in intense laser fields are a nice playground to study the coupling of intense electromagnetic radiation into matter. In particular, non-stationary plasma effects lead to pronounced dynamics in the optical response. Recent experiments have shown that excitation with optically delayed dual pulses provides a powerful way to control the coupling of the radiation to these finite systems. Both the yield of highly charged atomic ions [1] as well as the kinetic energy of emitted electrons [2] are strongly enhanced for a particular optimal delay. The significance of the temporal structure of the laser field is demonstrated by complementary Vlasov calculations [3] on model systems. These confirm that the distinct maximum in the charging efficiency can be attributed to plasmon-enhanced ionization of the expanding cluster [1].

Furthermore, by using intensity selective scanning the ionization threshold intensities leading to a given atomic charge state are determined. They exhibit a dramatic deviation when compared to the ionzation of single atoms. Comparative measurements between metal and rare gas clusters are discussed.

[1] T. Döppner et al., Phys. Rev. Lett. 94:013401, 2005
[2] T. Döppner et al., Phys. Rev. A 73:R031202, 2006
[3] Th. Fennel et al., Eur. Phys. J. D 29:367, 2004

Hauptvortrag SYCP 1.8 Di 18:00 5D

Initiation of ultracold plasma formation by long-range forces between Rydberg atoms — •Thomas Amthor, Markus Reetz-Lamour, Janne Denskat, and Matthias Weidemüller — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

It has been observed that a gas of ultracold Rydberg atoms spontaneously transforms into a plasma [1]. This plasma is created by an ionization avalanche due to electrons trapped in the potential well formed by the ions. The initial processes releasing the first electrons and thus triggering the ionization have long remained obscure. Collisions with hot background atoms and ionization by black-body radiation were possible candidates, but could not explain all observations. Recent experiments showed that collisions induced by long-range forces between the cold Rydberg atoms represent the main contribution to the inital ionization. The acceleration and subsequent Penning ionization of Rydberg atoms has been investigated under different conditions, the underlying interactions being either of dipole-dipole [2] or van der Waals type [3]. An overview over the effects of mechanical forces with respect to ionization and formation of ultracold plasmas is given. Experimental techniques to follow this process in real time and calculations based on a Monte Carlo model are presented. Scenarios for control and suppression of ionization in Rydberg gases are also discussed.

[1] M. P. Robinson et al., Phys. Rev. Lett. 85, 4466 (2000)
[2] W. Li et al., Phys. Rev. Lett. 94, 173001 (2005)
[3] T. Amthor et al., Phys. Rev. Lett. in press