Fachverband Atomphysik (A)

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Übersicht der Hauptvorträge und Fachsitzungen

(Hörsäle 3C, 3D, Poster C3, zeitweise 1A, 2F, 2G, 3F)

Hauptvorträge

A 1.1	Mo	14:00–14:30	3C	**Fragmenting multi-electron atoms: from single photons to attosecond pulses** — •Agapi Emmanouilidou
A 2.1	Mo	14:00–14:30	1A	**Cavity Optomechanics** — •Tobias J. Kippenberg
A 3.1	Mo	16:30–17:00	3C	**Coherent Control with Shaped Attosecond Soft-X-Rays: Techniques and Application** — •Thomas Pfeifer
A 4.1	Mo	16:30–17:00	1A	**Dynamical quantum phase transitions** — •Ralf Schuetzhold
A 5.1	Di	11:00–11:30	3C	**Time-resolved mapping of correlated electron emission from Helium atom in an intense laser pulse** — •Camilo Ruiz Mendez
A 7.1	Di	11:00–11:30	3D	**Vibrational spectroscopy of isolated metal clusters with a Free Electron Laser** — •André Fielicke, Philipp Gruene, Jonathan T. Lyon, Gerard Meijer
A 8.1	Di	14:00–14:30	3C	**Applications of laser aligned molecules** — •Henrik Stapelfeldt
A 15.1	Do	8:30– 9:00	3C	**Correlations and Quantum Electrodynamics effects in He-like uranium** — •m. trassinelli, a. kumar, h.f. beyer, c. brandau, h. bräuning, s. geyer, a. gumberidze, p. indelicato, p. jagodzinski, ch. kozhuharov, s. hess, r. märtin, r. reuschl, th. stöhlker, s. trotsenko, g. weber
A 20.1	Do	11:00–11:30	3C	**On the path towards table-top free-electron-lasers** — •Florian Gruener, Matthias Fuchs, Raphael Weingartner, Benjamin Marx, Stefan Becker, Dieter Habs
A 21.1	Do	11:00–11:30	3D	**Helium und die Tripelkollision - neue Skalierungsgesetze in Zweielektronenatomen** — Chang Woo Byun, Nark Nyul Choi, Min-Ho Lee, •Gregor Tanner
A 28.1	Fr	11:00–11:30	3C	**Nonlinear coherent transport of waves in disordered media** — •Thomas Wellens, Benoît Grémaud
A 29.1	Fr	11:00–11:30	3D	**Bridging atomic and nuclear physics in nuclear excitation by electron capture** — •Adriana Pálffy, Jörg Evers, Christoph H. Keitel

Fachsitzungen

A 1.1–1.6	Mo	14:00–15:45	3C	**Attosecond electron dynamics**
A 2.1–2.4	Mo	14:00–16:00	1A	**Quantum gases I (jointly with Q)**
A 3.1–3.6	Mo	16:30–18:15	3C	**Attosecond pulses and high harmonics (jointly with K and Q)**
A 4.1–4.5	Mo	16:30–19:00	1A	**Quantum gases II (jointly with Q)**
A 5.1–5.7	Di	11:00–13:00	3C	**Interaction with intense laser pulses I: Atoms**
A 6.1–6.7	Di	8:30–10:15	3D	**Interaction of matter with ions**
A 7.1–7.7	Di	11:00–13:00	3D	**Metal clusters**
A 8.1–8.7	Di	14:00–16:00	3C	**Interaction with intense laser pulses II: Molecules and beyond**
A 9.1–9.8	Di	14:00–16:00	2F	**Ultracold atoms I (jointly with Q)**
A 10.1–10.14	Di	16:30–18:30	Poster C3	**Posters: Atomic clusters**
A 11.1–11.9	Di	16:30–18:30	Poster C3	**Posters: Interaction with attosecond and VUV-light**
A 12.1–12.19	Di	16:30–18:30	Poster C3	**Posters: Interaction with intense laser pulses**
A 13.1–13.8	Di	16:30–18:30	Poster C3	**Posters: Photoionization and atomic systems in external fields**
A 14.1–14.17	Di	16:30–18:30	Poster C3	**Posters: Interaction of matter with ions**
A 15.1–15.7	Do	8:30–10:30	3C	**Precision spectroscopy I**

A 16.1–16.8	Do	8:30–10:30	3D	**Atomic Clusters**
A 17.1–17.7	Do	8:30–10:30	3F	**Collision processes and energy transfer I (jointly with MO)**
A 18.1–18.6	Do	8:30–10:00	2F	**Ultracold atoms II (jointly with Q)**
A 19.1–19.6	Do	8:30–10:00	2G	**Ultracold Rydberg gases (jointly with Q)**
A 20.1–20.7	Do	11:00–13:00	3C	**Experiments with FLASH and FEL perspectives: an overview**
A 21.1–21.7	Do	11:00–13:00	3D	**Atomic systems in external fields**
A 22.1–22.4	Do	11:00–12:15	3F	**Collision processes and energy transfer II (jointly with MO)**
A 23.1–23.8	Do	14:00–16:00	3C	**Precision spectroscopy II**
A 24.1–24.6	Do	14:00–15:30	3D	**Photoionization**
A 25.1–25.16	Do	16:30–18:30	Poster C3	**Posters: Precision spectroscopy of atoms and ions**
A 26.1–26.21	Do	16:30–18:30	Poster C3	**Posters: BECs, ultracold gases and plasmas**
A 27.1–27.12	Do	16:30–18:30	Poster C3	**Posters: Electron scattering and recombination**
A 28.1–28.5	Fr	11:00–12:30	3C	**Transport in ultracold gases and plasmas (jointly with Q)**
A 29.1–29.6	Fr	11:00–12:45	3D	**Electron scattering and recombination**
A 30.1–30.5	Fr	14:00–15:15	3C	**Precision spectroscopy III**
A 31.1–31.7	Fr	14:00–15:45	3D	**Interaction with intense laser pulses III: VUV and X-ray light**

Mitgliederversammlung des Fachverbands Atomphysik

Montag 13:30–14:00 Raum 3D

- Bericht
- Wahl des designierten Fachverbandsvorsitzenden
- Verschiedenes

A 1: Attosecond electron dynamics

Zeit: Montag 14:00–15:45 Raum: 3C

Hauptvortrag A 1.1 Mo 14:00 3C

Fragmenting multi-electron atoms: from single photons to attosecond pulses — •Agapi Emmanouilidou — University of Oregon

Attosecond collisions govern the ionization of multi-electron atoms by single photon absorption. These collisional processes are consistent with the electronic break-up geometry we predict for energies close to threshold. Confirming the predicted break-up geometries and observing in time these collisional patterns will be the impetus for future experiments. In single photon ionization the electronic correlation is essential for full fragmentation of many electron atoms. This is not the case when the atoms are driven by ultra-short laser pulses. We also discuss the correlated motion of the escaping electrons in multi-electron atoms driven by attosecond pulses.

A 1.2 Mo 14:30 3C

Attosecond time resolved momentum spectroscopy — •Ram Gopal, Konstantinos Simeonidis, Claus Dieter Schröter, Helga Rietz, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Electronic response times for outer-shell electrons in atoms or molecules, lie in the domain of tens to hundreds of attoseconds and are not accessible with 'conventional' ultra-fast laser technology, since the wavelength of visible lasers limits the pulse length to about 4 fs. Thus, attosecond pulses are required, successfully developed via high-harmonic generation (HHG) within the last five years and demonstrated to be able to trace electronic response times [1].We use ultra-short XUV pulses, typically hundreds of attoseconds long, to launch electronic wavepackets in atoms. Time delayed infrared pulses of moderate intensities(10^{13} to 10^{14} W/cm^2) probe the excited atoms by ionisation. In conjunction with 3D ion-electron coincidence momentum imaging of the products using a 'Reaction Microscope'[2], we setup a technique for the time-resolved observation of electronic dynamics.

[1] M. Uiberacker et. al., Nature, 446 627 (2007)
[2] J. Ullrich et al., Rep. Prog. Phys 66, 1463-1545 (2003).

A 1.3 Mo 14:45 3C

Composite quantum-mechanical and quasiclassical descriptions: Application to attosecond dynamics — •Ulrich Galster and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Dresden

The emergence of attosecond laser pulses challenges theoreticians to describe electronic dynamics in the time-domain. Pure quantum mechanical long time propagation in multiple dimensions still suffer from enormous computational requirements. Quasiclassical methods are more feasible in terms of computational effort, but often fail to describe quantum effects accurately. A worthwhile alternative is to use the advantages of both descriptions in a composition. Short time-intervals which exhibit dynamics of dominant quantum character can be described quantum-mechanically, while for the remaining time a quasiclassical method is used. At the moment of switching between both descriptions, the instantaneous quantum state is transformed into a quasi-classical phase-space distribution using the Wigner function.

A 1.4 Mo 15:00 3C

Monte-Carlo study of electronic dynamics in semiconductors with an ultrashort XUV-laser pulse — •Nikita Medvedev and Baerbel Rethfeld — Technische Universitaet Kaiserslautern, Kaiserslautern, Germany

We study theoretically the interaction of condensed matter with a new kind of ultrashort high-intensity XUV laser pulses (new light source FLASH at DESY in Hamburg). In our contribution we present first numerical simulations of the excitation and ionization of the electronic subsystem within a solid silicon target, irradiated with femtosecond laser pulse (25 fs, $\hbar\omega = 38$ eV). The Classical Trajectory Monte Carlo method was extended in order to take into account the electronic band structure for electrons excited into the conduction band. Secondary excitation and ionization processes were included and simulated event by event as well. The influence of the band structure on the redistribution of free electrons on subpicosecond time-scale is analyzed. In the presented work the temporal distribution of the density, the energy of these electrons, and their energy distribution function were calculated. It is demonstrated that due to the fact that part of the energy is spended to overcome ionization potentials and is kept by holes, the final kinetic energy of free electrons is much less than the total energy provided by the laser pulse. The final total number of electrons excited by single photon is significantly less than estimated by simplest expression $n_e = \hbar\omega/E_{\mathrm{gap}}$. We introduce the concept of an "effective band gap"for collective electronic excitation, which can be applied to estimate the free electron density after high-intensity XUV laser pulse.

A 1.5 Mo 15:15 3C

Imaging Attosecond Electron Wavepackets Around The Ionization Threshold — •Marko Swoboda[1], Thomas Remetter[1], Johan Mauritsson[1], Anne l'Huillier[1], Kenneth J. Schafer[2], Freek Kelkensberg[3], Wing-Kiu Siu[3], Per Johnsson[3], Marc J. J. Vrakking[3], Matthias F. Kling[4], Irina Znakovskaya[4], Thorsten Uphues[4], Sergey Zherebtsov[4], Franck Lépine[5], Enrico Benedetti[6], Federico Ferrari[6], Giuseppe Sansone[6], and Mauro Nisoli[6] — [1]Dept. of Physics, LTH, Lund University, P.O. Box 118, 221 00 Lund, Sweden — [2]Louisiana State Univ., Baton Rouge, Louisiana 70803-4001, USA — [3]AMOLF Institute, P.O.Box 41883, 1009 DB Amsterdam, The Netherlands — [4]MPI für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — [5]Univ. Lyon 1; CNRS; LASIM, UMR 5579,43 bvd. du 11 nov. 1918, 69622 Villeurbanne, France — [6]CUSBO, ULTRAS-INFM, Politecnico, Piazza Leonardo da Vinci 32, 20133 Milano, Italy

We image the momentum distributions of attosecond electron wavepackets generated from the ionization of Helium by attosecond XUV pulses. Using an infrared probing field, the evolution of these wavepackets can be captured in time and space. Tuning the central frequency of the pulses allows us to initiate a number of processes that originate from the interplay of partially bound and continuum wavepackets or returning electrons and the atomic potential. Using this attosecond pump-probe scheme, we can track electron dynamics around the ionization barrier, performing interferometric measurements of different ionization pathways.

A 1.6 Mo 15:30 3C

Creating and monitoring non-equillibrium plasmas with attosecond laser pulses — •Ionuţ Georgescu, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden, Germany

It has been shown by means of microscopic calculations that the charging of rare-gas clusters exposed to VUV laser pulses from an FEL can be traced with attosecond XUV laser pulses by measuring the kinetic energy of the photo electrons detached by the latter in a pump-probe experiment [1]. Given the rapid development of high-harmonic sources, it will soon be possible to implement this scheme in a table-top experiment, where both the VUV pump and the XUV probe can be generated from the same IR pulse. We show that with pump pulses as short as one femtosecond the charging process is accompanied by the formation of a nano-plasma, whose properties leave a strong fingerprint on the result of the probe. We predict that pump and probe pulses as short as 250 attoseconds can induce a and monitor the dynamics of a nano-plasma far from equilibrium, whose relaxation patterns resemble those of ultra-cold "micro-plasmas"[2].

[1] I. Georgescu, U. Saalmann and J.M. Rost *Phys. Rev. Lett.* 99, 183002 (2007)
[2] T.C. Killian, T. Pattard, T. Pohl and J.M. Rost *Phys. Rep.* 449, 77 (2007)

A 2: Quantum gases I (jointly with Q)

Zeit: Montag 14:00–16:00 Raum: 1A

Hauptvortrag A 2.1 Mo 14:00 1A

Cavity Optomechanics — •Tobias J. Kippenberg — Max Planck Institut fuer Quantenoptik

Achieving the quantum regime with mechanical objects offers fascinating possibilities for applied and fundamental Physics alike but has yet has been unattained so far. Remarkably, research groups working on mechanical systems ranging in size from nanometer-scale oscillators to centimeter-scale optical cavities to kilometer-scale gravity wave detectors are now all independently approaching a regime in which either the mechanical system or its interaction with the environment must be described quantum mechanically. These experiments will mark the beginning of the new research field of cavity Quantum Optomechanics. In this talk I will review our own efforts at the MPQ in this emerging research field; specifically, we have developed a novel laser cooling method (1,2) with which mechanical oscillators can be cooled - analogous to atomic laser cooling - and achieved unprecedented readout of mechanical motion. This technique provides a route towards ground state cooling of a mechanical oscillator. The mechanical oscillators in our work are provided by monolithic micro-cavities, which inherently combine mechanical and optical degree of freedom. I will describe the various efforts my group made towards achieving this interesting, yet highly challenging regime including the mechanical analog of Resolved Sideband Cooling.

References:
(1) A. Schließer et al. Phys. Rev. Lett. 97, 243905 (2006)
(2) I. Wilson-Rae et al. Phys. Rev. Lett. 99, 093901 (2007)

Gruppenbericht A 2.2 Mo 14:30 1A

Bose-Einstein condensates coupled to solid state systems on an atom chip — •Philipp Treutlein[1,2], David Hunger[1,2], Stephan Camerer[1,2], Pascal Böhi[1,2], Max Riedel[1,2], Johannes Hoffrogge[1,2], Theodor W. Hänsch[1,2], Daniel König[2], Jörg P. Kotthaus[2], and Jakob Reichel[3] — [1]Max-Planck-Institut für Quantenoptik, Garching — [2]Fakultät für Physik, Ludwig-Maximilians-Universität München — [3]LKB, Ecole Normale Superieure, Paris

We present the status of two experiments which explore the interaction of atoms with micro- and nanofabricated solid state systems on a chip.

The first experiment aims at coupling a BEC to the mechanical oscillations of a nanoscale cantilever with a magnetic tip. Theoretical investigations of the magnetic coupling mechanism show that the atoms can be used as a sensitive probe for the cantilever dynamics. At low temperatures, the backaction of the atoms onto the cantilever is significant and the system represents a mechanical analog of cavity QED in the strong coupling regime [P. Treutlein et al., Phys. Rev. Lett. 99, 140403 (2007)].

In the second experiment, the solid state system is a miniaturized microwave guiding structure, which can be used to manipulate BECs. Through microwave dressing of hyperfine states, state-selective double-well potentials can be created. Such potentials have applications in quantum information processing, the study of Josephson effects, and could be used to entangle atoms via state-selective collisions [P. Treutlein et al., Phys. Rev. A 74, 022312 (2006)].

Gruppenbericht A 2.3 Mo 15:00 1A

Dissipation Fermionizes a One-Dimensional Gas of Bosonic Molecules — •Dominik M. Bauer, Niels Syassen, Matthias Lettner, Thomas Volz, Daniel Dietze, Juan J. Garcia-Ripoll, Ignacio Cirac, Gerhard Rempe, and Stephan Dürr — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

Many-body systems usually behave differently depending on whether the particles are bosons or fermions. However, bosons are forced to behave much like fermions if the system is one-dimensional (1D) and the interactions dominate the dynamics. This strongly correlated system is called a Tonks-Girardeau gas [1,2] and was observed with atoms in optical lattices [3,4]. All this work dealt with conservative interactions. Here we demonstrate a surprising generalisation, namely that inelastic collisions produce a dissipative analogue of the Tonks-Girardeau gas. We report on an experiment with molecules confined to 1D in an optical lattice. Inelastic collisions between the molecules create strong correlations that suppress the molecule loss rate by a factor of about 10. We dramatically increase this suppression by adding a lattice along the 1D direction. We develop theory which agrees with our experimental observations. Our work offers perspectives to create other, and possible new, strongly correlated states using dissipation.

[1] Tonks, L. *Phys. Rev.* **50**, 955-963 (1936).
[2] Girardeau, M. *J. Math. Phys.* **1**, 516-523 (1960).
[3] Paredes, B. *et al. Nature* **429**, 277-281 (2004).
[4] Kinoshita, T. *et al. Science* **305**, 1125-1128 (2004).

Gruppenbericht A 2.4 Mo 15:30 1A

Strong dipolar effects in Chromium Bose-Einstein condensates (Gruppenbericht) — •Jonas Metz, Bernd Fröhlich, Tobias Koch, Thierry Lahaye, Axel Griesmaier, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart

The experimental observation of strong dipolar effects in a Bose-Einstein condensate of Chromium are presented. Starting with dipolar interactions which perturb the usual contact interactions, we use a Feshbach resonance to reduce and finally switch off the contact interaction. We investigate the stability diagram of a purely dipolar gas for various trap shapes and find a universal behaviour in the large N case for all dipolar gases. We then induce a dipolar collapse and study the dynamics. Quantitative comparison with theoretical calculations by the Ueda group of Tokyo University are presented. The symmetry of the dipolar interaction is observed in the collapse products.

A 3: Attosecond pulses and high harmonics (jointly with K and Q)

Zeit: Montag 16:30–18:15 Raum: 3C

Hauptvortrag A 3.1 Mo 16:30 3C

Coherent Control with Shaped Attosecond Soft-X-Rays: Techniques and Application — •Thomas Pfeifer — Departments of Chemistry and Physics, University of California & Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

Recent progress in ultrafast laser technology enables the generation of soft-x-ray pulses down to $\sim$ 100 attoseconds in duration, thus allowing access to the unexplored realm of electron dynamics. On the other hand, coherent control of matter with shaped laser fields has reached its maturity with regard to controlling the *relative motion of atoms* (vibrations/phonons, phase transitions, molecular reactions and rotation). However, due to the lack of laser pulse shaping techniques in the soft-x-ray spectral region, coherent control has so far had only limited capability of controlling the *electronic wavefunction* directly, which is of fundamental importance to physics (multi-electronic correlation) and chemistry (bonding dynamics). In this talk, it will be shown how Coherent Control can be transferred to, and combined with Attosecond Science towards the goal of gaining comprehensive mastery of matter on the quantum scale. Experimental results, theoretical concepts, and simulations demonstrate the feasibility of using a) multicolor laser fields, b) phase-shaped laser pulses, and c) medium control in high-harmonic generation to enable shaping of pulses and pulse trains in the attosecond soft-x-ray domain. Also, the first experimental application of shaped coherent soft-x-rays towards the optimal control of electronic quantum processes (dissociative photoionization of SF_6) will be presented.

A 3.2 Mo 17:00 3C

Molecular orbital tomography using short laser pulses — •Elmar van der Zwan, Ciprian Chirila, and Manfred Lein — Institute for Physics, University of Kassel, Germany

Recently a method to perform tomographic imaging of molecular orbitals using high-harmonic generation has been proposed [1]. The method is based on the simplification that the returning electron in the

three-step model can be modeled as a plane wave. Orbitals of arbitrary symmetry can be reconstructed if one uses extremely short laser pulses that ensure the continuum wave packet recombines from one side only. We compare two different forms for the reconstruction, and introduce an error-reduction algorithm that can be used to optimize the results. One of the challenges of the scheme lies in the accurate determination of the continuum wave packet. We determine the continuum wave packet in the Lewenstein model, assuming that the molecular orbital is known, and compare this with various methods to determine the continuum wave packet without knowledge of the orbital.

[1] J. Itatani, J. Levesque, D. Zeidler, H. Niikura, H. Pépin, J.C. Kieffer, P.B. Corkum and D.M. Villeneuve. *Tomographic imaging of molecular orbitals*. Nature 432, 867-871 (2004)

A 3.3 Mo 17:15 3C

Dressing and high-order harmonic generation in small molecules — •Ciprian Chirila and Manfred Lein — Universität Kassel, Institute of Physics, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

The strong-field approximation was recently extended to take into account the effect of vibrational motion and laser-induced coupling of the Born-Oppenheimer states on high-harmonic generation in molecules. We present detailed calculations of the harmonic spectra in H_2 and D_2 for long laser wavelengths (2000 nm), comparing the effects of the dressing to the case of 800 nm. The main effect of dressing is an overall reduction of the harmonic generation and, at long wavelengths, a non-negligible change in the ratio of harmonic signals from different isotopes.

A 3.4 Mo 17:30 3C

Extended Strong-Field Approximation including Collectivity — •Michael Ruggenthaler and Dieter Bauer — Max-Planck-Institut für Kernphysik, Heidelberg

High-order harmonic generation may often be treated within a single active electron picture using the so-called strong-field approximation (SFA) [1] to propagate the initial wave-function. However, if collective phenomena are to be included the standard SFA treatment will not suffice. Although the SFA may be extended via an extra term in the Hamiltonian accounting for the collective behavior of the multi-electron system, there is no straightforward definition of this term.

The problem can be reformulated in time-dependent density-functional theory [2,3] where the so-called Kohn-Sham orbitals are propagated such that total single-particle density is the same as those of the interacting system. The linear response of the density to the external potential gives rise to a time-dependent Hartree-exchange-correlation potential which then can be used within the framework of the extended SFA.

[1] W. Becker et al, Phys. Rev. A 56, 645 (1996)
[2] E. Runge and E. K. U. Gross, Phys. Rev. Lett. 52, 997 (1984)
[3] M. A. L. Marques et al, Time Dependent Density Functional Theory, Lect. Notes Phys. 706 (Springer, Heidelberg, 2006)

A 3.5 Mo 17:45 3C

Formation of Amplitude and Phase during High Harmonic Generation — •Markus Gühr, Brian K. McFarland, Joe P. Farrell, and Philip H. Bucksbaum — Stanford PULSE Center, Stanford University and SLAC, California, USA

High Harmonics of a laser field are generated during the interaction of an intense laser pulse with an atomic or molecular gas. The amplitude and phase of the harmonics contain information about the generation process and the symmetry of the electronic wave functions of the involved atoms or molecules [1].

We measure the amplitude of high harmonics generated in N_2 and Ar. Furthermore, we obtain the relative phase between the harmonics from N_2 and Ar by interferometric measurements on mixtures of the two gases. We observe phase jumps at the 33rd and the 25th harmonic. The first is accompanied by an amplitude minimum in Ar and attributed to a Cooper minimum. The second is accompanied by an amplitude minimum and a linewidth broadening in N_2. It results from the symmetry of the N_2 highest occupied molecular orbital.

The discussed phenomena have important implications for the amplitude and phase of attosecond pulses generated via high harmonic generation.

[1] M. Gühr, B. K. McFarland, J. P. Farrell and P. H. Bucksbaum, J. Phys. B: At. Mol. Opt. Phys., 40, 3745-3755 (2007)

A 3.6 Mo 18:00 3C

Enhancement of high-order harmonic generation by rare gas mixtures — •Mirko Prijatelj, Tobias Vockerodt, Daniel Steingrube, Uwe Morgner, and Milutin Kovacev — Institut für Quantenoptik, Leibniz Universität Hannover

We study the enhancement of high-order harmonic generation (HHG) by rare gas mixtures. Our experiment confirms recent results mixing He and Xe atoms. The harmonics from Xe atoms enhance the observed yield from He atoms by about two orders of magnitude. Moreover the cut-off position is extended compared to the spectrum of pure He atoms. We report on the experimental parameter sensitivity of the enhancement process and show first results which indicate that the atomic state structure is an important prerequisite. Our investigation extends as well towards experimental conditions suited for low-energy pump pulses as for example mode-locked Ti:sapphire femtosecond oscillator pulses with MHz repetition rates. These conditions are interesting for generating harmonics either intracavity or directly from a femtosecond oscillator. This experimental approach promises to lead to a joint frontier of precision spectroscopy and ultrafast science by extending frequency comb technology into the XUV spectral region.

A 4: Quantum gases II (jointly with Q)

Zeit: Montag 16:30–19:00 Raum: 1A

Hauptvortrag A 4.1 Mo 16:30 1A

Dynamical quantum phase transitions — •Ralf Schuetzhold — TU Dresden, Institut fuer Theoretische Physik

A sweep through a quantum phase transition by means of a time-dependent external parameter entails non-equlilibrium phenomena (break-down of adiabaticity): Since the energy gap vanishes at the critical point, the response time diverges and thus the external time-dependence drives the system away from the ground state (assuming zero temperature initially). In this way, the initial quantum fluctuations are amplified and may become observable. By means of several examples based on ultra-cold atoms, possible effects of these amplified quantum fluctuations are studied and universal features (such as freezing) are discussed.

Gruppenbericht A 4.2 Mo 17:00 1A

Bose-Einstein condensates in presence of defects and disorder. — •Tobias Paul, Mathias Albert, Nicolas Pavloff, and Patricio Leboeuf — Laboratoire de Physique Théorique et Modèles Statistiques, Universite Paris Sud, F-91405 Orsay

Superfluidity and Anderson localization are genuine many-body manifestations of quantum coherence which are nowadays revisited in dilute Bose gases. Recent theoretical results obtained in our group in Orsay are reviewed: First, we study the coherent flow of interacting Bose-condensed atoms in presence of a single defect or an extended disorder potential. We discuss the different regimes of quantum transport induced by a variation of the condensate flow-velocity v: We point out that for v much smaller than the sound velocity c the flow is in general superfluid, whereas beyond a critical velocity the formation of solitons and shockwaves sets on. For $v \gg c$, a regime of quasi-dissipationless transport is found. There, for long disorder samples, the system enters an Anderson localized phase.

In a second step, we consider the experimental relevant case where a harmonic trap is superimposed to the defect potential. We obtain a global picture characterizing the dynamical properties of the dipole oscillations where we recover the different regimes of quantum transport introduced in the first part of the talk. We discuss our findings in the context of recent experiments [1,2] and address the question under which circumstances Anderson localization could be observed.

[1] J. E. Lye et al., Phys. Rev. A 75, 061603 (2007)
[2] P. Engels and C. Atherton, Phys. Rev. Lett. 99, 160405 (2007)

Gruppenbericht A 4.3 Mo 17:30 1A

Tailoring quasi-particles in ultra-cold matter: soliton oscillations, longest lifetimes and fillings. — •Christoph Becker[1], Parvis Soltan-Panahi[1], Simon Stellmer[1], Sören Dörscher[1], Eva-Maria Richter[1], Mathis Baumert[1], Jochen Kronjäger[1], Kai Bongs[1,2], and Klaus Sengstock[1] — [1]Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg — [2]Midlands Centre for Ultracold Atoms, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK

Solitons are distinguishing features of many non-linear physical systems. Stabilized by a balance between spreading due to dispersion and focusing mediated by non-linearities, solitons emerge as non-spreading wavepackets. BEC's provide fascinating possibilities concerning quantum-state engineering, necessary for the creation and observation of solitons. Dark solitons appear as dips in the density distribution and have so far been produced in few experiments limited by very short lifetimes.
Here we report on the generation of dark solitons in an optically trapped ^{87}Rb BEC with an extraordinary life-time of up to several seconds. For the first time, we observe oscillations of dark solitons with a characteristic frequency in excellent agreement with theoretical predictions. By filling the dark soliton with atoms in another hyperfine state we are able to create dark-bright solitons with a substantially greater oscillation period.
The experimental results are combined with theoretical studies based on the Gross-Pitaevskii equation.

Gruppenbericht A 4.4 Mo 18:00 1A

Strongly interacting Fermi gases in an optical lattice — •Henning Moritz[1], Niels Strohmaier[1], Robert Jördens[1], Kenneth J. Günter[1,2], Yosuke Takasu[1,3], Michael Köhl[1,4], and Tilman Esslinger[1] — [1]Institute of Quantum Electronics, ETH Zürich, Hönggerberg, CH-8093 Zürich, Switzerland — [2]Department for Electronic Science and Engineering, Kyoto University, Japan — [3]Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, United Kingdom — [4]Laboratoire Kastler Brossel, 24, rue Lhomond, 75005 Paris

When fermionic atoms are placed in the periodic potential of an optical lattice, they behave very much like electrons in a solid. However, the properties of this synthetic material can be changed at will. Here, we report on the experimental realization and investigation of strongly interacting Fermi gases with tunable interactions.

By changing the attractive interaction strength we are able to control the transport properties: while dipole oscillations are observed for a non-interacting gas, the cloud relaxes very slowly to its equilibrium position for strong attractive interactions. We suggest an interpretation in the framework of the Hubbard model including external confinement. The strong attraction induces bound states, which can only tunnel very slowly via second order processes.

Furthermore, experiments on the behavior of repulsive Fermi gases will be presented.

Gruppenbericht A 4.5 Mo 18:30 1A

First Bose-Einstein Condensate in microgravity — •Tim van Zoest[1], Wojtek Lewoczko-Adamczyk[2], and Anika Vogel[3] for the QUANTUS-Collaboration — [1]Institut für Quantenoptik, Leibniz-Universität Hannover — [2]Institut für Physik, Humboldt Universität Berlin — [3]Institut für Laserphysik, Universität Hamburg

Promising techniques for fundamental tests in the quantum domain are matter-wave sensors based on cold atoms, which use atoms as unperturbed microscopic test bodies for measuring inertial forces or as frequency references. Microgravity is of high relevance for matter-wave interferometers and experiments with quantum matter, like Bose-Einstein-condensates , as it permits the extension of an unperturbed free fall in a low-noise environment.

The project QUANTUS is a feasibility study of a compact, robust and mobile experiment for the creation of a BEC in a weightlessness environment at the droptower in Bremen (ZARM). The experiment has to be implemented in a dropcapsule with a length of 215 cm and 60 cm diameter and has to withstand forces up to 50 g (1). The experimental setup as well as the latest results, the realization of the first weightlessness Bose-Einstein Condensate with longest time of flights and the adiabatic expansion to very shallow traps (less than 20 Hz), are described. In future, the apparatus will serve as an experimental platform to investigate various aspects of ultra-cold gases in microgravity like adiabatic release, extended coherent evolution and features of atom lasers.

(1) A. Vogel et al., Appl. Phys. B, 84, 04 (2006)

A 5: Interaction with intense laser pulses I: Atoms

Zeit: Dienstag 11:00–13:00 Raum: 3C

Hauptvortrag A 5.1 Di 11:00 3C

Time-resolved mapping of correlated electron emission from Helium atom in an intense laser pulse — •Camilo Ruiz Mendez — Max-Planck-Institut für Physik komplexer Systeme Nöthnitzer Straße 38 01187 Dresden

We apply and analyze the concept of mapping ionization time onto the final momentum distribution to the correlated electron dynamics in the non-sequential double ionization of Helium in a strong laser pulse ($\lambda = 800$ nm) and show how the mapping provides insight into the double ionization dynamics. To this end, we study by means of numerical integration of the time dependent Schroedinger equation of a fully correlated model atom the temporal evolution of the center-of-mass momentum in a short laser pulse.

Our results show that in the high intensity regime ($I_0 = 1.15 \times 10^{15}$ W/cm^2) the mapping is in good agreement with a classical model including binary and recoil rescattering mechanisms. In the medium intensity regime ($I_0 = 5 \times 10^{14}$ W/cm^2) we identify additional contributions from the recollision-induced excitation of the ion followed by subsequent field ionization (RESI).

A 5.2 Di 11:30 3C

Wavelength Dependence of Strong-Field Non-Sequential Multiple Ionization — •Manuel Kremer[1], Artem Rudenko[1], Bettina Fischer[1], Oliver Herrwerth[1], Vitor de Jesus[2], Karl Zrost[1], Georg Gademann[1], Konstantin Simeonidis[1], Thorsten Ergler[1], Bernold Feuerstein[1], Claus Dieter Schröter[1], Robert Moshammer[1], and Joachim Ullrich[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg — [2]Centro Federal de Educação Tecnológica de Química de Nilópolis, Rio de Janeiro, Brazil

We present recoil-ion momentum distributions for Non-sequential double and multiple ionization (NSDI, NSMI) of Ar and Ne by 1300nm laser pulses (pulse duration 35-40fs, peak intensity $3-5*10^{14} W/cm^2$) measured with a *Reaction Microscope*, and compare them with our earlier results at 800nm. The spectra at both wavelengths can be consistently interpreted within a simple semiclassical model which we developed earlier in order to explain atomic structure dependence observed at 800nm. There two mechanisms of NSDI have been considered: (i) direct (e,2e) ionization by the returning electron and (ii) recollision-induced excitation with subsequent field ionization (RESI). A deeper minimum at zero longitudinal momentum for 1300nm is shown to be due to the suppression of the contribution from the latter channel. In good agreement with the results of the calculation, we found that at both wavelengths RESI mechanism is more important for Ar than for Ne.

A 5.3 Di 11:45 3C

Experiments on non-sequential double ionization of Ne and Ar using a femtosecond laser oscillator — •Yunquan Liu[1], Sebastian Tschuch[1], Martin Dürr[1], Artem Rudenko[1], Robert Moshammer[1], Joachim Ullrich[1], Martin Siegel[2], and Uwe Morgner[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]University of Hannover, Welfengarten 1, D-30167 Hannover, Germany

We report on first proof-of-principles results on non-sequential double ionization of argon and neon achieved by using a newly developed long-cavity Ti:sapphire femtosecond oscillator with a pulse duration of 45 fs and a repetition of 6.2 MHz combined with a dedicated reaction microscope. Under optimized experimental conditions, peak intensities larger than 2.3×10^{14} W.cm^{-2} have been achieved. Ion momentum distributions were recorded for both rare gases and show significantly

different features for single as well as for double ionization. For single ionization of neon a spike of zero-momentum electrons is found when decreasing the laser intensity towards the lowest ionization rate we can measure which is attributed to a non-resonant ionization channel. As to double ionization, the longitudinal momentum distribution for Ne^{2+} displays a clear double-hump structure whereas this feature is found to be smoothened out with a maximum at zero momentum for Ar^{2+}.

A 5.4 Di 12:00 3C

Density-functional approach to strong-field electron dynamics of the Helium atom — •Mark Thiele and Stephan Kümmel — Physikalisches Institut, Universität Bayreuth, 95440 Bayreuth

Time-dependent density-functional theory is a formulation of quantummechanics that uses the density as the basic variable. In principle, it provides a computationally attractive approach to non-perturbative processes. We investigate its performance by applying it to the one-dimensional Helium atom in a strong laser field. Specifically, we analyze an approximation of the correlation-potential that is adiabatic in time but exact otherwise. Our results show that this approximation yields excellent results for processes like the Helium double ionization. This finding has important consequences for the development of density-functionals for strong-field processes.

A 5.5 Di 12:15 3C

Ionization dynamics of multiply charged ions in intense laser fields — •Henrik G. Hetzheim, Guido R. Mocken, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

The ionization dynamics is an essential process of the interaction of atoms with intense laser fields [1]. In order to compensate the high atomic field strength in hydrogen-like multiply charged ions, strong laser fields are necessary to stimulate the ionization dynamics. We focus on the investigation of the initial ionization process, when the electron leaves the nucleus. The angular distribution of the outgoing electron provides a tool to determine the associated field strength [2], which is experimentally difficult to measure [3]. The analysis of the ionization process is carried out by solving the Dirac equation in two dimensions, where the magnetic field force of the laser field is taken into account.

[1] Y. I. Salamin, S. X. Hu, K. Hatsagortsyan, C. H. Keitel, Phys. Reports **427**, 41–155 (2006)
[2] in preparation
[3] G. A. Mourou, T. Tajima, S. V. Bulanov, Rev. Mod. Phys. **78**, 309–371 (2006)

A 5.6 Di 12:30 3C

Long-orbit effects in nonsequential double ionization — •Sergey Popruzhenko[1], Nikolay Shvetsov-Shilovski[2], Sergey Goreslavski[2], and Wilhelm Becker[3] — [1]Max-Planck Institut für Kernphysik, Heidelberg, Deutschland — [2]Moscow Engineering Physics Institute, Moscow, Russia — [3]Max-Born-Institut, Berlin, Deutschland

Basic quantum processes with atoms and molecules subject to intense laser fields, including above-threshold ionization, generation of high-order harmonics and nonsequential double ionization (NSDI), can be described and understood within the concept of complex quantum trajectories (orbits). The quantum orbits approach not only allows us to evaluate transition amplitudes, which are inaccessible by other methods, but also provides a simple semiclassical picture capable of predicting new effects. Usually the quantum orbit shortest in time provides the major contribution to the probability amplitude, while the long orbits are of minor importance, due to the photoelectron wave packet spreading. In this work, we show that in the case of NSDI in elliptically polarized light long orbits corresponding to the second and the third returns of the photoelectron to its parent ion contribute more than the first one. We discuss a qualitative effect based on the left-right asymmetry in the electron-electron correlation spectra, which permits us to discriminate the return contributing most under certain conditions. We also propose an experimental scheme for the visualization of this effect.

A 5.7 Di 12:45 3C

Strong field tunneling without ionization — Thomas Nubbemeyer[1], •Karsten Gorling[1], Alejandro Saenz[2], Ulli Eichmann[1], and Wolfgang Sandner[1] — [1]Max Born Institut, Max Born Str 2a 12489 Berlin — [2]AG Moderne Optik, Institut für Physik, Humboldt-Universität zu Berlin

In the tunneling regime of strong laser field ionization we measure a substantial fraction of neutral atoms surviving the laser pulse in excited states. The measured neutral atom yield extends over several orders of magnitude as a function of laser intensity. Our findings are compatible with the strong field tunneling-plus-rescattering model, confirming the existence of a widely unexplored neutral exit channel which originates from tunneling within a narrow range of the laser field phase (*frustrated tunneling ionization*). Both quantum mechanical and semi-classical calculations show that the interaction with combined Coulomb and laser fields leads to a neutral excited state distribution centered around $n = 6 - 10$, in agreement with the experimental results.

A 6: Interaction of matter with ions

Zeit: Dienstag 8:30–10:15 Raum: 3D

A 6.1 Di 8:30 3D

A MOTRIMS experiment on the energy dependence of double electron transfer — •Ina Blank[1], Simone Götz[1], Terry Mullins[1], Wenzel Salzmann[1], Roland Wester[1], Matthias Weidemüller[1], Valeriu Gabriel Hasan[2], Reinhard Morgenstern[2], and Ronnie Hoekstra[2] — [1]Physikalisches Institut, Universität Freiburg, Hermann-Herder Str. 3, 79104 Freiburg, Germany — [2]KVI - Atomic Physics, University of Groningen, Zernikelaan 25, NL-9747 AA Groningen, The Netherlands

We present the first results on the energy dependence of state-selective double-electron capture in ion-alkali collisions. Experiments are performed with an O^{6+} projectile beam, passing through a cloud of sodium atoms, stored in a magneto-optical trap. State resolved double electron transfer is observed by detecting Na^{2+} ions using Recoil-Ion-Momentum-Spectroscopy [1]. Laser cooling of target atoms ensures high momentum resolution due to low initial thermal momenta. Projectile ion energies are varied from 4.5 to 8.6 keV/amu. Recoil momenta of Na^{2+} ions reveal double transfer of outer and inner shell target electrons, principally into 3ln'l' states of the doncharged projectile [2]. Due to the short interaction times for transfer into 3l3l' states, double transfer into this channel is expected to occur simultaneously which suggests that coherent multi-particle correlations may be investigated via this process.

[1] J. W. Turkstra et al., Phys. Rev. Lett. 87, 123202 (2001).
[2] S. Knoop et al., Europhys. Lett., 74, 992, (2006)

A 6.2 Di 8:45 3D

Einfluss der Molekülorientierung von H_2^+-Projektilen auf die Dynamik der Stoßionisation von He — •Jan- Philipp Suske[1], Shao Feng Zhang[1,3], Daniel Fischer[4], Siegbert Hagmann[2], Andreas Krauss[1], Kai- Uwe Kühnel[1], Robert Moshammer[1] und Joachim Ullrich[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Gesellschaft für Schwerionenforschung, Planckstr. 1,64291 Darmstadt, Germany — [3]Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou, 730000, China — [4]Stockholm University, AlbaNova University Centre, 10 691 Stockholm, Sweden

Werden H_2^+-Molekülionen beschleunigt und zur Kollision mit kalten He-Atomen gebracht, kann das atomare Target bei gleichzeitiger Dissoziation des Projektilmoleküls ionisiert werden. Mit Hilfe eines Reaktionsmikroskops erhält man die vollständige kinematische Information über das ionisierte Target sowie die emittierten Elektronen. Ladung und Impulse der Projektilfragmente ergeben sich mit Hilfe eines Analysemagneten und zweier positionsempfindlicher Detektoren. Aus den Impulsen der Molekülfragmente lässt sich die Orientierung des Moleküls zum Zeitpunkt des Stoßes rekonstruieren. Insbesondere der Einfluss der Molekülorientierung des H_2^+ auf die Ionisation des Targets wurde untersucht.

A 6.3 Di 9:00 3D

Development of a Drift Time Spectrometer for Heavy Element Research — •Mustapha Laatiaoui[1], Michael Sewtz[1], Dieter Habs[1], Hartmut Backe[2], Werner Lauth[2], and Peter Kunz[2] — [1]Department für Physik, LMU München, Am Coulombwall 1, D-85748 Garching, Germany — [2]Institut für Kernphysik, Universität Mainz, D-55099 Mainz,Germany

Atomic and chemical properties of the heaviest elements are strongly influenced by relativistic effects. Theoretical calculations of ionic radii yield relativistic contractions of the valence orbitals, which show individual trends for different electronic configurations; an effect that may be exploited for element identification of superheavy ions.

Ion mobility spectrometry presents the most direct method to probe these calculations. This technique is well established for stable elements to determine the ionic mobility K by the drift time of ions along electric field lines inside a noble gas filled buffer gas cell. From collision cross sections, which are inverse proportional to K, ionic radii can be inferred.

Due to the low production rates and short half-lifes of the heaviest elements, ultra-sensitive experimental methods are needed. A suitable experimental setup is beeing developed, which will permit the determination of the ion mobility of short-lived nuclei with a precision of $\delta K/K < 10^{-2}$. A status report of this project will be given. This work is supported by the BMBF(06ML236I).

A 6.4 Di 9:15 3D

Energieverlust und Reichweitenstreuung relativistischer Uranionen — •B. Riese[1], H. Weick[2], H. Geissel[1,2], R. Knoebel[1,2], M. Maier[2], M. Matos[2], N. Nankov[2], W. Plass[1], M. Portillo[2], C. Scheidenberger[1,2] und M. Winkler[2] — [1]Justus Liebig Universität Giessen — [2]Gesellschaft für Schwerionenforschung Darmstadt

Die Abbremsung von Schwerionen im Energiebereich (100-1000) A MeV wurde mit dem Magnetspektrometer FRS der GSI untersucht. Der Energieverlust hängt vom mittleren Ladungszustand in der Materie ab. Uranionen sind in diesem Energiebereich noch nicht vollständig ionisiert, deshalb wurde die Ladungsverteilung in verschiedenen Targetmaterialien bestimmt. Wird der mittlere Ladungszustand korrekt berücksichtigt, sind die gemessenen Energieverluste in guter Übereinstimmung mit den theoretischen Vorhersagen. Die Energieverluststreuung in dicken Targets wurde zum einen mit Hilfe der Dispersion des Spektrometers und der Ortsverteilung aufgenommen. Zum anderen wurden die Ionen hinter dem Target vollständig abgebremst und deren Reichweitenstreuung bestimmt. Hierzu wurde hinter dem Target ein Abbremser variabler Dicke verwendet und die Zählrate vor und hinter dem Abbremser mit Hilfe von zwei Ionisationskammern gemessen. Der Einfluss verschiedener Ladungszustände führt zu einer deutlichen Vergrößerung der Energiebreiten. Die Reichweitenverteilungen sind wichtig beim gezielten Implantieren, wie z.B. von in Kernreaktionen bei hoher Energie produzierter Nuklide in einer gasgefüllten Stoppzelle. Aus dieser können dann Strahlen seltener Isotope bei niedriger Energie extrahiert werden.

A 6.5 Di 9:30 3D

Spectral shape of two-photon decay from 2s state in He-like Tin — •ajay kumar[1], sergiy trotsenko[1,2], andrei volotka[3], dariusz banas[4], heinrich beyer[1], harald bräuning[1], alexandre gumberidze[1], siegbert hagmann[1,2], sebastian hess[1,2], christophor kozhuharov[1], regina reuschl[1,2], uwe spillmann[1,2], martino trassinelli[1,5], günter weber[1,6], and thomas stöhlker[1,6] — [1]Atomic Physics Group, GSI, Darmstadt, Germany — [2]University of Frankfurt, Germany — [3]TU Dresden, Germany — [4]Swietokrzyska Academy, Kielce, Poland — [5]Institut des NanoSciences de Paris, France — [6]Universität Heidelberg, Germany

The (1s2s) 2^1S_0 state of He-like ions decays to the ground state via two-photon electric dipole (2E1) transitions. The study of the spectral shape of this 2E1 decay mode in He-like ions is of interest due to its sensitivity to electron-electron correlations and quantum electrodynamical effects. In the present investigation a novel experimental approach has been applied to study two-photon transitions in few-electron high-Z ions. Relativistic collisions of Li-like projectiles with a gaseous target were used to form the desired initial state, which allowed for a measurement of the undistorted two-photon spectral shape. The decay of the 2^1S_0 state in He-like tin was measured, following a successful earlier experiment with He-like uranium. The continuum shape of the two-photon energy distribution was compared with fully relativistic calculations, which are Z-dependent. With the present technique we could, for the first time, observe Z-dependent effects in the spectral shape.

A 6.6 Di 9:45 3D

A critical test for distorted wave theories: laser-assisted single ionization by ion impact — •Marcelo Ciappina[1] and Lars Bojer Madsen[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, D-01187 Dresden, Germany — [2]Department of Physics and Astronomy, Univ. of Aarhus, 8000 Aarhus C, Denmark

We study single ionization in laser-assisted high-energy non-relativistic ion-atom collisions and show that the low-energy angular differential electron spectrum may be enhanced significantly by a weak external field. With increasing the strength of the assisting field, the energy spectrum develops a plateau with a characteristic cut-off [1]. In the plateau region we predict distinct multiphoton peaks separated by the photon-energy of the laser field. In the present laser-assisted continuum-distorted-wave eikonal-initial-state (LA-CDW-EIS) theory, this effect may be related to the dynamics in the two-body electron-projectile subsystem. First-order type theories, e.g. the laser-assisted distorted wave Born (LA-DWB) [2] and first Born approximation (LA-FBA) [3], do not account for the phase-distortion of the target electron by the incoming projectile and consequently the associated plateau, cut-off and multiphoton features are absent. The combined process where an electron is ionized by a heavy ion and subsequently moves in the laser field and under the influence of the Coulomb fields of the projectile and the target represents a stringent test for distorted wave theories. [1] M. F. Ciappina and L. B. Madsen, Phys. Rev. A, (submitted). [2] ibid, J. Phys. B 39 5057 (2006). [3] A. Voitkiv and J. Ullrich, J. Phys. B 34 1673 (2001); ibid, 34 4383 (2001).

A 6.7 Di 10:00 3D

Direct laser acceleration of ions for application in cancer radiotherapy — •Z. Harman[1], Y.I. Salamin[1,2], and C.H. Keitel[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]American University of Sharjah, POB 26666, Sharjah, United Arab Emirates

Linearly and radially polarized multi-terawatt and petawatt laser beams, focused to sub-wavelength waist radii, can directly accelerate protons and carbon nuclei, over micron-size distances, to the energies required for hadron cancer therapy. Radially polarized beams have better emittance than their linearly polarized counterparts. We put forward direct laser acceleration of ions as an appealing alternative for utilization in cancer therapy, once the refocusing of ion beams accelerated by linearly polarized lasers is experimentally solved or radially polarized pulses of sufficient power can be produced. Using a table-top laser system to accelerate the ions may results in a cut on the cost and physical space required by the construction of a conventional accelerator. This scheme may also be a better candidate than the ion production and acceleration by a laser-solid-target method.

A 7: Metal clusters

Zeit: Dienstag 11:00–13:00 Raum: 3D

Hauptvortrag A 7.1 Di 11:00 3D

Vibrational spectroscopy of isolated metal clusters with a Free Electron Laser — •André Fielicke, Philipp Gruene, Jonathan T. Lyon, and Gerard Meijer — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin

Small particles often differ considerably in their properties from the bulk material. This has triggered a large interest in the study of matter on the nano-scale, but the basic determination of the structures of nano-materials on an atomic scale can be exceedingly difficult. However, knowing the atomic arrangements of the clusters is one of the crucial ingredients that is needed for understanding their physical and chemical properties. Particularly sensitive to the internal cluster structure is vibrational spectroscopy, since it directly maps the bonding

forces and, in its appropriate variant, it is susceptible to the cluster symmetry. We have recently demonstrated far-infrared multiple photon dissociation (far-IR-MPD) spectroscopy on transition metal cluster rare-gas complexes as a method to obtain the vibrational spectra in the range of their structure-specific vibrational fundamentals. The intense and tunable far-IR radiation needed for this is delivered by the Free Electron Laser for Infrared eXperiments FELIX. IR-MPD spectroscopy on the metal-cluster rare-gas complexes combined with quantum chemical calculations allows for the determination of the cluster structures. As examples we will discuss the growth behaviour of clusters of the group 5 transition metals (V, Nb, Ta) and of pure and doped silicon clusters.

A 7.2 Di 11:30 3D

Melting temperatures and latent heats of oxidized sodium clusters — •Christian Hock, Samuel Strassburg, Christof Bartels, Hellmut Haberland, and Bernd v.Issendorff — Fakultät für Mathematik und Physik,Universität Freiburg, Stefan-Meier-Str. 19, 79104 Freiburg

Melting points and latent heats of oxidized Na cluster cations $(Na_n O_2)^+$ in the size range $n = 135 \ldots 191$ have been measured. The results are compared to earlier measurements performed on pure Na clusters [1]. The cluster ions are produced in a sodium evaporation source and oxidized by the addition of O_2 after exiting the aggregation tube. Then they are thermalized in a heat bath (helium 0.7 mbar) with controllable temperature (6 K... 350 K).
A significant lowering of the melting points and the latent heats is observed. The variation of the melting temperature with cluster size for oxidized sodium clusters is remarkably similar to the one of pure sodium cluster. Furthermore there seems to be a correlation between the melting points of a Na_n^+ cluster and the corresponding $(Na_n + 2O_2)^+$ cluster; the difference of their melting temperatures is always around 16 K. The latent heat is always reduced and the variation with cluster size is similar to the one of pure sodium clusters.
For a selected cluster size of $n = 144$ sodium atoms additional caloric curves have been measured for higher degrees of oxidation for 4 and 6 additional oxygen atoms. As expected, both the melting points and the latent heats are reduced further.
[1] H. Haberland *et al.*, Phys. Rev. Lett. **94**, 035701 (2005)

A 7.3 Di 11:45 3D

Winkelaufgelöste Photoelektronenspektroskopie an kalten Natrium-Clustern — •Christof Bartels, Jan Huwer, Christian Hock und Bernd von Issendorff — Fakultät für Mathematik und Physik, Universität Freiburg, Stefan-Meier-Straße 21, 79104 Freiburg

Winkel- und energieaufgelöste Photoelektronenspektren von größenselektierten Na_n^--Clustern ($n = 3 \ldots 268$) nach Anregung mit ns-Laserpulsen mit 308 nm und 500 nm wurden gemessen. Zur Verbesserung der Auflösung der Spektren wurden die Cluster in einer RF-Ionenfalle auf etwa 20 K gekühlt. Für ausgewählte Clustergrößen $(3, 4, 5, 7, 19, 33, 34, 55, 147)$ wurden zusätzlich mit einem Farbstofflaser Spektren als Funktion der Wellenlänge in kleinen Schritten im Bereich von 250 bis 755 nm gemessen.

Die Winkelverteilungen der auslaufenden Photoelektronen liefern Informationen über die Drehimpulse der Elektronen im Cluster, denn sie entstehen aus der Überlagerung derjenigen Partialwellen, die sich aus dem jeweiligen Anfangszustand gemäß den Auswahlregeln für Einphotonenabsorption $\Delta l = \pm 1$ und $\Delta m = 0$ bilden lassen. Diese Winkelverteilungen sind durch einen einzigen Anisotropieparameter β charakterisiert.

Die Experimente zeigen eine starke Abhängigkeit der Winkelverteilungen der Photoelektronen von der Clustergröße, vom elektronischen Zustand und von der Wellenlänge des anregenden Lichts. Sowohl für sehr kleine (Na_5^-) als auch für größere Cluster (Na_{147}^-) wurden bei bestimmten Wellenlängen Übergänge mit negativem β-Parameter beobachtet.

A 7.4 Di 12:00 3D

$L_{2,3}$-Röntgenabsorptionsspektroskopie an freien, massenselektierten Metallclustern in einer Tieftemperaturionenfalle — •Konstantin Hirsch[1], Vicente Zamudio-Bayer[1], Jochen Rittmann[1], Philipp Klar[1], Marlene Vogel[1], Fabian Lofink[1], Andreas Langenberg[1], Robert Richter[1], Bernd von Issendorff[2], Thomas Möller[1] und Tobias Lau[1] — [1]Institut für Optik und Atomare Physik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin — [2]Fakultät für Physik, Universität Freiburg, Stefan-Meier-Straße 21, 79104 Freiburg

Mit Hilfe der Röntgenabsorptionsspektroskopie wurde erstmals die lokale, unbesetzte Zustandsdichte an freien, massenselektierten Übergangsmetallclusterionen gemessen. Sämtliche Spektren wurden mit Ionenausbeutespektroskopie an der $L_{2,3}$-Kante an der Synchrotronstrahlungsquelle BESSY aufgenommen. Die Cluster wurden mit einer Magnetronsputterquelle erzeugt, in einem Quadrupolmassenfilter selektiert und anschliessend in einer Quadrupolionenfalle gespeichert, um sie mit weicher Röntgenstrahlung anzuregen. Anschliessend wurden sie aus der Falle extrahiert und in einem Flugzeitmassenspektrometer detektiert. Diskutiert werden massenaufgelöste Röntgenabsorptionsspektren von Vanadium im Größenbereich von V^+ bis V_{10}^+. Deutlich ist das verschwinden der atomaren Multiplettstruktur bei Clustergrößen von 4-5 zu erkennen, einzig das Linienverhältnis L_2/L_3 behält annähernd atomaren Charakter.

A 7.5 Di 12:15 3D

Resonante Röntgenabsorptionsspektroskopie an massenaufgelösten Übergangsmetallclustern in der Gasphase — •Jochen Rittmann[1], Vicente Zamudio-Bayer[1], Konstantin Hirsch[1], Marlene Vogel[1], Fabian Lofink[1], Philip Klar[1], Bernd von Issendorff[2], Thomas Möller[1] und Tobias Lau[1] — [1]Technische Universität Berlin, IOAP, EW 3-1, Hardenbergstr. 36, D-10623 Berlin — [2]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Str. 21, D-79104 Freiburg

Nach resonanter 2p-3d Anregung mit weicher Röntgenstrahlung wurde die Ionenausbeute von Übergangsmetallclustern (Ti, V, Co) gemessen. Durch die hochaufgelösten Massenspektren können mehrfach geladene Cluster erkannt werden, wodurch es erstmals möglich ist, die Röntgenabsorptionspektren an freien Clustern in der Nähe der L_3/L_2 Kante massenaufgelöst darzustellen. Mit diesen XAS-Ionenausbeutespektren ist es uns möglich Größenabhängigkeiten der Cluster zu bestimmen. Die energetische Lage dieser Resonanzen gibt dabei Aufschluß über die Spin-Bahn-WW der 2p Elektronen. Aus dem Verhältnis der Intensitäten der L_3/L_2 Resonanzen kann ein gradueller Übergang vom Atom zum Festkörper hin verfolgt werden. Die Form der Resonanzlinien gibt dabei Aufschluß über die unbesetzte Zustandsdichte des jeweiligen Übergangsmetallclusters. Aus dem Vergleich von verschiedenen Ladungszuständen der Cluster bei unterschiedlichen Anregungsenergien kann eine Fragmentation dieser Cluster beobachtet werden. Diese gibt Aufschluß über die Stabilität der Cluster und ist für die Interpretation der Spektren von Interesse.

A 7.6 Di 12:30 3D

Directed Emission of Fast Electrons from Excited Metal Nanoparticles — •Johannes Passig, Thomas Fennel, Nguyen Xuan Truong, Josef Tiggesbäumker, and Karl-Heinz Meiwes-Broer — Universität Rostock, Institut für Physik, Universitätsplatz 3, 18051-Rostock, Germany, www.physik.uni-rostock.de/cluster

Experimental studies on laser excited silver particles reveal a strong asymmetric electron emission characteristic giving electron kinetic energies of up to 1.3 keV in the direction of the laser polarization axis. It could be shown that in a dual pulse experiment the evolution of the plasmon frequency following the pump pulse enables resonant excitation by the probe pulse. The resulting electron energies, gained in the nanometer scaled microplasma, as well as the spatial asymmetry in emission direction cannot be explained by a conventional hydrodynamical or a purely coulomb driven expansion process.

We present a novel acceleration mechanism through plasmon assisted, phase-matched electron-cluster rescattering (SPARC) [1], which is capable to explain the generation of a directed emission of high energy electrons obtained in the experiment. Moreover, Vlasov simulations show that an attosecond electron pulse train is generated.

[1] Th. Fennel, T. Döppner, J. Passig, Ch. Schaal, J. Tiggesbäumker, and K.-H. Meiwes-Broer, Phys. Rev. Lett. 98, 143401 (2007)

A 7.7 Di 12:45 3D

X-ray Absorption Spectroscopy of Size-Selected Metal Clusters: Neutral Beam vs. Ion Trap — •Tobias Lau[1], Konstantin Hirsch[1], Philipp Klar[1], Andreas Langenberg[1], Fabian Lofink[1], Robert Richter[1], Jochen Rittmann[1], Marlene Vogel[1], Vicente Zamudio-Bayer[1], Bernd von Issendorff[2], and Thomas Möller[1] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, Hardenbergstraße 36, D-10623 Berlin — [2]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg

Combining the element specific nature of inner-shell excitation with size-selected transition metal and semiconductor clusters yields a

powerful technique to study cluster size and composition dependent changes in the electronic structure. Very recently, the first X-ray absorption spectra of free, size selected transition metal cluster cations could be recorded at the Berlin synchrotron radiation facility BESSY II. For small transition metal clusters ($n \leq 10$), the evolution of the $L_{2,3}$ edges from the monomer towards bulk can be followed atom by atom. While very small ($n = 2-4$) transition metal clusters show structured spectra similar to the monomer cation, already around $n = 5$ the clusters develop bulk-like X-ray absorption line shapes. These spectra will be discussed in comparison to XAS of size-selected, deposited clusters and of slightly larger transition metal clusters, investigated in a neutral beam.

A 8: Interaction with intense laser pulses II: Molecules and beyond

Zeit: Dienstag 14:00–16:00 Raum: 3C

Hauptvortrag A 8.1 Di 14:00 3C

Applications of laser aligned molecules — •Henrik Stapelfeldt — Department of Chemistry, University of Aarhus, Denmark

Moderately intense, non-ionizing laser pulses can align molecules along axes fixed in the laboratory [1]. This talk will initially discuss recent results aimed at controlling the 3-dimensional alignment of asymmetric top molecules. In particular, we show how a long laser pulse can strongly confine one axis of a molecule while a second, much shorter pulse, sets the molecule into controlled rotation about the axis arrested. As a result strong 3D alignment occurs immediately after the short pulse and is repeated periodically reflecting the revolution about the axis aligned. Our method opens new directions for field-free 3D alignment and for controlling internal rotations of molecules [2].

Second, we report the first experimental observations of orientationally resolved photoelectron angular distributions using laser aligned molecules [3]. The effect is illustrated by field-free aligned carbon disulfide molecules singly ionized by multiphoton absorption from an intense 800 nm pulse. The experimental results are compared to calculations with the strong field approximation.

[1] H. Stapelfeldt and T. Seideman, Rev. Mod. Phys., 75, 543 (2003). [2] S. S. Viftrup, V. Kumarappan, S. Trippel, H. Stapelfeldt E. Hamilton and T. Seideman, Phys. Rev. Lett., 99, 143602 (2007). [3] V. Kumarappan, et al., to be submitted (2007).

A 8.2 Di 14:30 3C

Electron-nuclear correlation in above-threshold-ionization of molecular hydrogen — •Stefan Pieper[1] and Manfred Lein[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Institut für Physik, Universität Kassel, Heinrich-Plett-Straße 40, 34132 Kassel, Germany

The ionization of molecules in strong, short laser pulses leads due to the absorption of many photons to "ATI peaks" in the kinetic-energy spectrum of the emitted electron. Because of the occupation of various vibrational levels of the remaining ion, the ATI peaks are smeared out. This is a consequence of energy loss for some electrons in favor of the ionic vibration. The numerical simulation of a model hydrogen molecule via solving the time-dependent Schrödinger equation shows that the intrinsic, discrete energy scale of the vibrational levels leads to the observation of novel correlation effects such as spectral enhancements within the rescattering plateau for certain vibrational states.

A 8.3 Di 14:45 3C

Ionization and fragmentation of C_{60} fullerenes as a function of the fs laser light ellipticity — •Ihar Shchatsinin[1], Tim Laarmann[1], Nick Zhavoronkov[1], Claus Peter Schulz[1], and Ingolf Volker Hertel[1,2] — [1]Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy, Max-Born-Str. 2a, D-12489 Berlin, Germany — [2]Department of Physics, Free University Berlin, Arnimallee 14, D-14195 Berlin, Germany

The C_{60} fullerene is an interesting model to study the interaction dynamics of a large but finite system with strong laser fields. In the current work we have investigated the effect of the laser radiation ellipticity on the ionization and fragmentation of C_{60} utilizing both time-of-flight mass and photoelectron spectroscopy. A strong influence of the light ellipticity on the formation of fragments and parent ions was found for 27 fs laser pulses centred at 800 nm in the intensity range between 0.5×10^{14} W/cm^2 and 4.3×10^{14} W/cm^2. For the lower laser intensities photo ionization and photo fragmentation yields decrease with increasing ellipticity, while for the highest laser intensities the yields show a rise when the laser polarization is changed from linear to circular. It clearly indicates that recollisions during the strong field excitation can play only a minor role under the present experimental conditions. Possible theoretical models explaining these results will be discussed in detail. Comparison between the experimental observations and theoretical description allows to obtain new information about properties of C_{60} and to make a further step towards full understanding of fs laser induced dynamics in large and complex systems.

A 8.4 Di 15:00 3C

Einfachionisation kleiner, ausgerichteter Moleküle in starken Laser-Feldern — •Moritz Meckel[1], André Staudte[1,2], Daniel Comtois[3], Dirk Zeidler[2,4], David Villeneuve[2], Paul Corkum[2] und Reinhard Dörner[1] — [1]Institut für Kernphysik, J. W. Goethe-Universität Frankfurt, Max-von-Laue-Straße 1, Frankfurt, Deutschland — [2]National Research Council, 100 Sussex Drive, Ottawa, Ontario, Kanada — [3]INRS-Énergie, Matériaux et Télécommunications, 1650 boul. Lionel-Boulet, Varennes, Québec, Kanada — [4]Carl Zeiss SMT AG, Rudolf-Eber-Straße 2, Oberkochen, Deutschland

Mittels der Technik der "impulsiven Molekülausrichtung" ("Impulsive Molecular Alignment") ist es möglich, die räumliche Orientierung der Achsen kleiner Moleküle zu kontrollieren.
Die Impulse von Elektronen, die bei der Einfachionisation derart ausgerichteter N_2- und O_2-Moleküle in starken ($I = 3 \cdot 10^{14} \frac{W}{cm^2}$), nicht-resonanten ($\lambda = 800nm$), ultrakurzen ($\tau = 40fs$) Laser-Pulsen entstehen, wurden mithilfe der COLTRIMS-Technik bestimmt. Die Elektronen-Impulsverteilungen aus "alignten" und "anti-aligneten" Molekülen werden verglichen.

A 8.5 Di 15:15 3C

Finite-size, geometry, and many-electron effects in strong field ionization — •Dieter Bauer[1] and Sergey Popruzhenko[1,2] — [1]Max Planck Institute for Nuclear Physics, Heidelberg, Germany — [2]Moscow State Engineering Physics Institute, Moscow, Russia

We investigate the strong field ionization dynamics of finite-size systems such as metal clusters and C_{60}. By comparing the results from the numerical solution of the time-dependent Schrödinger equation in single active electron approximation with those from time-dependent density functional theory (i.e., the solution of the corresponding time-dependent Kohn-Sham equation) we identify the role of the collective electron motion inside the target system. By comparing, e.g., the results for C_{60} with those for a metal cluster of the same size we identify the role of the geometry of the target. We find that the non-adiabatic dynamics inside the target may lead to extended cut-offs in the above-threshold ionization spectra which depend on the laser frequency and the target size. The geometry of the target affects the angular distribution of the photoelectrons.

A 8.6 Di 15:30 3C

Laser-assisted pair creation — •Erik Lötstedt, Ulrich D. Jentschura, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

We present results on the laser-assisted Bethe-Heitler pair creation process. With Bethe-Heitler pair creation is understood the process where an electron-positron pair is created by a photon with energy $\hbar\omega$ in the vicinity of a nucleus. We study the modification of this process in the presence of a strong laser field, however with a peak electric field strength below the critical Schwinger field. The matrix element is related to that of laser-assisted bremsstrahlung [1,2] by a crossing symmetry. Especially interesting is here the transition from $\hbar\omega < 2mc^2$, where the process is laser-induced, to the laser-assisted case where $\hbar\omega > 2mc^2$. Here ω is the angular frequency of the non-laser mode photon, and m the electron mass. Also treated is a novel algorithm for the numerical evaluation of generalized Bessel functions, a type of special function occurring in the theoretical description of laser-matter interaction.

[1] E. Lötstedt, U. D. Jentschura, and C. H. Keitel, Phys. Rev. Lett.

98, 043002 (2007).
[2] S. Schnez, E. Lötstedt, U. D. Jentschura, and C. H. Keitel, Phys. Rev. A **75**, 053412 (2007).

A 8.7 Di 15:45 3C

Magnetic-field effects in electron-positron pair creation by counterpropagating laser pulses — •Matthias Ruf, Guido R. Mocken, Carsten Müller, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

Until now the study of electron-positron pair production by counterpropagating laser fields has been based on the approximation of neglecting the spatial dependence of the field. We employ a numerical approach [1] by propagating a negative-energy Dirac electron on a two-dimensional grid via the split-operator algorithm. This enables us to take the magnetic field of the laser pulses into account. We show that for high frequencies the creation process is strongly affected: the production probability is reduced, the resonant Rabi-oscillation pattern is significantly modified and the resonance positions are shifted and multiplied [2].

[1] G. R. Mocken and C. H. Keitel, J. Comp. Phys. 199, 558 (2004)
[2] M. Ruf, G. R. Mocken, C. Müller, K. Z. Hatsagortsyan and C. H. Keitel: in preparation

A 9: Ultracold atoms I (jointly with Q)

Zeit: Dienstag 14:00–16:00 Raum: 2F

A 9.1 Di 14:00 2F

Cold bosonic atoms in a $\pi-$flux lattice — •Stephan Rachel and Martin Greiter — Institut für Theorie der Kondensierten Materie, Universität Karlsruhe, 76128 Karlsruhe

We present a model where the rare phenomenon of fragmented Bose–Einstein condensation occurs: we consider a system of neutral, bosonic atoms on a square lattice subject to an effective magnetic field. We focus on a magnetic flux of half a Dirac flux quantum through every lattice cell. The effective flux yields two minima in the lower single particle band. We show that in the many particle ground state, the particles are evenly distributed over both minima. The two macroscopically occupied minima correspond to two distinct Bose condensates.

Regarding the low-energy excitations of the system, we show that Josephson tunneling is only possible for pairs of bosons, while single particle tunneling between both condensates is absent. We further find a massive mode describing fluctuations in the relative density of the two condensates.

A 9.2 Di 14:15 2F

Bose-Einstein condensation in a periodic potential: A perturbation approach — •Ming-Chiang Chung[1], Victor Lopez-Richard[2], Carlos Trallero-Giner[3], and Andreas Buchleitner[4] — [1]Max-Planck-Institut für Physik Komplexer Systeme* Noethnitzer Str. 38, D-01187 Dresden, Germany — [2]Departamento de Fisica, Universidade Federal de S\˜{a}o Carlos, 13.565-905, S\˜{a}o Carlos, S\˜{a}o Paulo, Brazil — [3]Faculty of Physics, Havana University, 10400 Havana, Cuba — [4]Quantum Optics and Statistics Institute of Physics Albert-Ludwigs-Universitaet Freiburg Hermann-Herder-Str. 3 D-79104 Freiburg, Germany

Considering the Gross-Pitaevskii equation for Bose-Einstein condensate in a stationary one dimensional optical lattice with period d in reduced coordinates, we are able to formally obtain closed analytical solutions for the order parameter and for the chemical potential. We report solutions for different range of values for the repulsive and the attractive non-linear interactions in the condensate and laser parameters creating the lattice. We have preformed a quantitative analysis with numerical solutions and theoretical estimation of the reported analytical equations allowing the determination of validity ranges of the perturbation approach. This study gives a very useful result establishing the universal range of the non-linear coupling term and lattice parameter values where each solution can be easily implemented.

A 9.3 Di 14:30 2F

Improving the analytical determination of bound state energies and scattering lengths in molecular potentials – especially near threshold — •Patrick Raab and Harald Friedrich — Physik Department T30a, Technische Universität München, D-85747 Garching

Conventional WKB quantization can be improved substantially by including the appropriate reflection phases at the classical turning points. By application of the Effective-Range-theory we are able to calculate the reflection phase at the outer turning point in an attractive potential up to linear order in energy. For arbitrary energy we estimate the reflection phase by matching the low energy expansion with known formulas for high energies. This model, which includes only one free parameter is a significant improvement over the approximate eigenenergies obtained by other methods. The scattering length is completely determined by the knowledge of one of the highest bound energy levels (not necessarily by the highest one) and the asymptotic behavior of the potential.

A 9.4 Di 14:45 2F

Jost-Functions & Attractive Singular Potentials — •Florian Arnecke, Javier Madronero, and Harald Friedrich — Physik Department T30a, Technische Universität München, D-85747 Garching

We use Jost-functions to determine the leading and next-to-leading terms of the phase shifts $\delta_l(k)$ in the case of homogeneous attractive singular potentials $-1/r^\alpha$, $\alpha > 2$, for arbitrary angular momentum l with incoming boundary conditions at small distances. The Jost-solutions are obtained by solving a Volterra-equation and a more general ansatz is used to fit the Jost-solutions to the WKB-waves in the inner region, where the WKB-approximation is accurate. A connection between the phase shifts of attractive and repulsive homogeneous singular potentials is presented.

A 9.5 Di 15:00 2F

Stable dark solitons in three-dimensional dipolar Bose-Einstein condensates — •Rejish Nath[1], Paolo Pedri[2], and Luis Santos[1] — [1]Institute of Theoretical Physics, Leibniz university of Hannover, Appelstrasse 2, 30167, Hannover, Germany — [2]Laboratoire de Physique Théorique de la Matière Condensée, Université Pierre at Marie Curie, case courier 121 , 4 place Jussieu, 75252 Paris Cedex, France

We study the dynamical stability of dark solitons in dipolar Bose-Einstein condensates. In the absence of non-locality due to the dipolar interaction, stationary dark solitons (nodal planes) are unstable against transversal excitations (snake instability) in 2D and 3D. On the contrary, due to its non local character, the dipolar interaction allows for stable 3D stationary dark solitons. We discuss in detail the conditions to achieve this stability, which demand the use of an additional optical lattice.

A 9.6 Di 15:15 2F

Correlation dynamics of strongly-correlated lattice bosons out of equilibrium — •Karen Rodriguez and Luis Santos — Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover

We analyze by means of matrix product states techniques the dynamics of strongly-correlated Bose gases in a finite one-dimensional optical lattice after a change of the lattice parameters within the superfluid region. We analyze different regimes of perturbation, which range from adiabatic to non-adiabatic. In particular, we are interested in the evolution of different correlations in the system in time, showing that the different correlations present different time scales in their reaction to the change of parameters. As a consequence, when local quantities are converged correlation to distant neighbours or the quasi-condensate fraction may still present a significant dynamics. In addition, the different time scales for different correlations open the possibility to have different criteria for adiabaticity in the system.

A 9.7 Di 15:30 2F

Laser Cooling and Trapping of a Leaky System: Barium — •Subhadeep De, Joost van den Berg, Aran Mol, Klaus Jungmann, and Lorenz Willmann — KVI, University of Groningen,

Groningen, The Netherlands

Heavy alkaline earth elements like radium are excellent candidates to test fundamental symmetries by searches for permanent electric dipole moments and atomic parity violation. Sensitive experiments require the trapping of these isotopes. Nevertheless, the two electron atoms have no simple two-level system for laser cooling due to the strong transitions between the singulet and the triplet system. The strongest transition from the ground state $^1S_0$-$^1P_1$ show a leak of 1:500 to metastable D-states. We have studied such a system with barium, where the branching into the D-states is 1:330(30). Repumping from these states uses the same excited state as the cooling transition, which leeds to coherent Raman transitions. Trapping and cooling of barium requires a set of seven lasers running at the same time. We report on the first successful trapping of barium in a magneto optical trap. The performance of the cooling and trapping will be discussed.

A 9.8 Di 15:45 2F

Non-Abelian Statistics in a Quantum Antiferromagnet — •Martin Greiter and Ronny Thomale — Institut für Theorie der Kondensierten Materie, Universität Karlsruhe, D 76128 Karlsruhe

We propose a novel spin liquid state for a S=1 antiferromagnet in two dimensions. The ground state is a spin-singlet, fully invariant under the symmetries of the underlying lattice, and possess a threefold topological degeneracy. The spinon and holon excitations obey non-abelian statistics, with the braiding of half-quantum vortices governed by zero energy modes in the vortex cores. We present numerical evidence that the universality class of this topological liquid can be stabilized by a model Hamiltonian involving three-spin interactions. We discuss possible realizations with polar molecules in optical lattices as well as potential applications in quantum computing.

A 10: Posters: Atomic clusters

Zeit: Dienstag 16:30–18:30 Raum: Poster C3

A 10.1 Di 16:30 Poster C3

Laser-Driven Electron Acceleration in Metal Nanoparticles — •Christian Schaal[1], Johannes Passig[1], Thomas Fennel[1], Tilo Döppner[2], Josef Tiggesbäumker[1] und Karl-Heinz Meiwes-Broer[1] — [1]Institute of Physics, University of Rostock, Universitätsplatz 3, 18051 Rostock, Germany. — [2]Lawrence Livermore National Lab, USA.

Silver clusters Ag_N(N=500..2000) generated with a magnetron sputtering source are irradiated with intense dual fs laser pulses (I_{laser}=10^{13}...10^{14} W/cm^2). In previous experiments we have demonstrated that the charging of the clusters can be enhanced by the resonant excitation of the dipolar mode leading to the emission of delocalized electrons. A comparison of energy and angular resolved measurements of the electron emission with microscopic analysis of corresponding semiclassical simulations indicates strong temporal beating in the electron emission at resonance and identifies phase-matched electron-cluster recollisions leading to multi-plasmon deexcitation, to produce the observed directional emission of most energetic electrons along the laser polarization axis, induced by resonant plasmon excitation at optimum pulse delay [1].

[1] Th. Fennel *et al.*, Phys. Rev. Lett. **98**, 143401 (2007).

A 10.2 Di 16:30 Poster C3

Aufbau eines Mikrowellenreaktors zur CVD-Synthese von Diamantclustern — •David Wolter, Lasse Landt, Thomas Möller und Christoph Bostedt — IOAP - Technische Universität Berlin

Diamantwachstum aus thermisch zersetztem Wasserstoff- und Methanradikalen in CVD (chemical vapour deposition) Reaktoren ist seit etwa zwei Jahrzehnten ein aktives Gebiet der Forschung. Eine Möglichkeit die benötigten Radikale zu erzeugen ist die Reaktionsgase in Mikrowellen - Plasmareaktoren zu zersetzen.

Wir studieren verschiedene Mikrowellenreaktor-Designs zur CVD Synthese von Diamantclustern. Zur Ausbildung der stehenden Welle ist die Geometrie des Reaktors von zentraler Bedeutung. Die Mikrowelleneinkopplung wurde zunächst am Computer simuliert und eine optimale Geometrie für maximale Energieeinkopplung bestimmt. Der Übergang vom Rechteckhohlleiter zum zylindrischen Resonator des Reaktors wurde entsprechend der Simulationen angefertigt, um einen möglichst verlustfreien Übergang von der rechteckigen Mode zur zylindrischen Mode zu realisieren. Erste Versuche mit der resultierenden Reaktorgeometrie ein stabiles Ar-Plasma zu erzeugen verliefen erfolgreich.

A 10.3 Di 16:30 Poster C3

Erzeugung von intensiven, ultrakurzen Laserpulsen durch Weißlichtfilamentation in Argongas - Experiment und Simulation — •Robert Irsig[1], Nguyen Xuan Troung[1], Thomas Fennel[1], Tilo Döppner[2], Josef Tiggesbäumker[1] und Karl-Heinz Meiwes-Broer[1] — [1]Universität Rostock, Institut für Physik, Universitätsplatz 3, 18051 Rostock — [2]Lawrence Livermore National Laboratory, Livermore, CA 94551 USA

Durch die Fokussierung von kurzen, intensiven Laserpulsen (<50fs, 2mJ) in eine mit Argon gefüllte Gaszelle werden Weißlichtfilamente erzeugt. In diesen Filamenten kommt es durch Selbstphasenmodulation zu einer spektralen Verbreiterung der Pulse. Nichtlineare Effekte, wie z.B. Self-Steepening, führen gleichzeitig zu einer Verringerung der Pulslänge auf unter 10fs [1]. Es wird gezeigt, wie die Filamente experimentell durch Variation von Gasdruck, Pulsenergie, Pulslänge sowie Pulsform beeinflußt werden können. Die Charakterisierung der so erzeugten Pulse erfolgt durch einen Single-Shot-FROG. In einer Simulation wird die Propagation der Laserpulse im Filament durch Lösung der nichtlinearen Schrödingergleichung beschrieben. Der Einfluß von Selbstphasenmodulation, Self-Steepening und Plasmabildung wird diskutiert.

[1] G. Stibenz, N. Zhavoronkov, and G. Steinmeyer, Opt. Lett. 31, 274 (2006)

A 10.4 Di 16:30 Poster C3

Multistep ionization of Argon clusters in intense femtosecond XUV laser pulses — •Mathias Arbeiter and Thomas Fennel — Institute of Physics, University of Rostock

The ionization dynamics of Argon clusters in ultrashort and intense XUV laser pulses is investigated by molecular dynamics simulation. Corresponding experiments[1] at FLASH free electron laser at $\lambda = 32\,\mathrm{nm}$ and intensities of I$\sim 10^{12-14}$W/cm^2 have demonstrated the cluster response to be completely different to the behavior observed in the infrared and the VUV regime, where plasma heating processes dominate the laser-cluster coupling. In the XUV regime, in contrast to that, the measured photoemission spectra indicate a series of direct electron emission events in the developing cluster Coulomb field, which eventually induces frustration of the photoemission at a certain level of ionization. In our MD analysis we focus on the impact of multi-electron effects, thermalization, and ionic motion within the interaction process and corresponding signature in the electron and ion emission spectra.

[1] C. Bostedt et al., submitted

A 10.5 Di 16:30 Poster C3

Optical Properties of Clusters — •Thomas Raitza, Heidi Reinholz, and Gerd Röpke — Universität Rostock

The measurements of optical properties are relevant for plasma diagnostics. The investigation of reflectivity and absorption of electromagnetic waves in inhomogeneous media will be done with special attention to laser excited clusters. Interactions of cluster systems with intense laser pulses were investigated via MD simulation.

Via MD simulation the current auto correlation function (ACF) was calculated. Optical properties derived from current ACF will be presented. The cluster size dependence of the optical properties will be discussed as well as thermodynamic relations and the influence of the laser field.

A 10.6 Di 16:30 Poster C3

3p-Absorptionsspektroskopie an neutralen Vanadiumclustern in der Gasphase — •Marlene Vogel[1], Konstantin Hirsch[1], Philipp Klar[1], Andreas Langenberg[1], Fabian Lofink[1], Jochen Rittmann[1], Vicente Zamudio-Bayer[1], Bernd von Issendorff[2], Thomas Möller[1] und Tobias Lau[1] — [1]Technische Universität Ber-

lin, Institut für Optik und Atomare Physik, EW 3-2, Hardenbergstraße 36, D-10623 Berlin — [2]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg

Die resonante 3*p*-Photoabsorption freier neutraler Vanadiumcluster wird vorgestellt. Die Cluster werden in einer Magnetronsputterquelle erzeugt und der neutrale Clusterstrahl mit Synchrotronstrahlung angeregt. Die im Zerfall des angeregten Zustands entstehenden Ionen werden mit einem gepulsten Wiley-McLaren-Flugzeitmassenspektrometer nachgewiesen. Erst eine genaue Analyse des Ladungszustands der erzeugten Clusterionen erlaubt eine Interpretation der Ionenausbeutespektren als Röntgenabsorptionsspektren. Als Resultat konnten Größenabhängigkeiten in der 3*p*-Photoabsorption kleiner Vanadiumcluster im Größenbereich von $n = (21 - 50)$ mit einer Größenauflösung von $n \pm 1$ nachgewiesen werden. Dabei zeigen besonders die Ladungszustände der Clusterionen nach der 3*p*-Anregung eine deutliche Größenabhängigkeit. Der Vergleich mit dem Spektrum des neutralen Vanadiumatoms zeigt, dass die Spektren der kleineren Cluster dem des Atoms ähnlicher sind als die der größeren Cluster.

A 10.7 Di 16:30 Poster C3

Angularly resolved photoelectron spectroscopy of Na clusters: Simple models — •Jan Huwer, Christof Bartels, Christian Hock, and Bernd v.Issendorff — Fakultät für Mathematik und Physik, Universität Freiburg, Stefan-Meier-Str. 21, 79104 Freiburg

Measurements of angularly resolved photoelectron spectra of negatively charged free sodium clusters ($n = 19 \ldots 147$) with ns-laser pulses ($\lambda = 290 \ldots 755$ nm) have been performed.

Energy-resolved photoelectron spectra of sodium clusters can be explained in the framework of the so-called Jellium model in most cases. In this model, the experimentally observed shell structure is explained by assuming that the atomic valence electrons can be treated as particles in an effective single-particle potential. The question is whether this one-particle picture also holds for excitation processes. If this was the case, the angular distributions could be calculated in analogy to one-electron atoms as shown by Bethe. The shape of the angular distributions can be reduced to one asymmetry parameter β, which only depends on the radial transition matrix elements and the scattering phases of the outgoing partial waves.

By assuming single-particle potentials of box and Woods-Saxon type, β parameters have been calculated for the experimentally investigated states. As observed in the experiment, the angular distributions show a strong dependence on the excitation energy. Furthermore we identified some general characteristics of the angular distributions for different orbital momentum states.

A 10.8 Di 16:30 Poster C3

Ionization of Argon dimers in intense laser fields — •Birte Ulrich, Lutz Foucar, Zenghu Chang, Horst Schmidt-Böcking, and Reinhard Dörner — Institut für Kernphysik, Universität Frankfurt, Deutschland

The ionization mechanisms of dimers with synchrotron radiation via Interatomic Coulombic Decay and Two-Step-1 have been well studied in the last view years. In this experiment we investigate the double ionization of Argon dimers in ultrashort (30 fs) intense laser pulses.The COLTRIMS-technique allows us to measure all charged particles with 4 Pi angle and high accuracy. Thus we are able to reconstruct the initial momenta and deduce the angular distribution of coincident Ar+ pairs. The first results will be presented for circular and linear polarization.

A 10.9 Di 16:30 Poster C3

Heliumdimere untersucht in langsamen Stössen mit Ar^{2+} — •Jasmin Titze, Markus Schöffler, Hong-Keun Kim, Robert Grisenti, Lothar Schmidt, Nadine Neumann, Ottmar Jagutzki, Horst Schmidt-Böcking und Reinard Dörner — Johann Wolfgang Goethe-Universität, Frankfurt, Germany

Heliumdimere stellen das am weitesten gebundene atomare System dar; die Bindungslänge kann die von C60 übersteigen. In Stössen mit Ar^2+ bei Projektilenergien von 25 keV/u wurde die Zerfallsdynamik nach Elektroneneinfang (ein und zweifach) mittels der COLTRIMS-Technik (COLd Target Recoil Ion Momentum Spectroscopy) untersucht.

A 10.10 Di 16:30 Poster C3

Comparing Resonant 2p X-ray Absorption of Size-selected Cobalt Clusters on Cu(100) and in a Linear Paul Trap — •Vicente Zamudio-Bayer[1], Leif Glaser[2], Konstantin Hirsch[1], Philipp Klar[1], Andreas Langenberg[1], Fabian Lofink[1], Robert Richter[1], Jochen Rittman[1], Marlene Vogel[1], Wilfried Wurth[2], Thomas Möller[1], Bernd von Issendorff[3], and J. Tobias Lau[1] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, EW 3-1, Hardenbergstraße 36, D-10623 Berlin — [2]Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, D-22761 Hamburg — [3]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg

Its element specificity makes resonant X-ray absorption spectroscopy an ideal tool to study deposited clusters at low coverage. At the 2*p* absorption edges of small, size-selected cobalt clusters on Cu(100), two separate sets of lines are observed which can be interpreted in terms of atomic-like multiplet splitting. For very small clusters ($n = 1, 2, 3$), these absorption lines show a strong size dependence. The size evolution of 2*p* X-ray absorption will be discussed in comparison to size-selected free cobalt clusters, recorded recently on mass selected cluster ions in a linear Paul trap at BESSY. Direct comparison of free and deposited clusters under well defined conditions allows to distinguish size-specific properties from cluster–substrate interaction effects. A shift to higher photon energies in deposited clusters indicates screening by substrate valence electrons.

A 10.11 Di 16:30 Poster C3

Ultrafast Dynamics of Neutral Sodium-Doped Water Clusters — •HongTao Liu, Jan Philippe Müller, Claus Peter Schulz, Christian Schröter, Nickolai Zhavoronkov, and Ingolf-Volker Hertel — Max-Born-Institute, Berlin, Germany

By doping pure water clusters with sodium atoms, the valence electron of sodium interacts with the dipole field of the water clusters. For $Na(H_2O)_n$ clusters with increasing size $n \geq 4$ the atomic 3s electron gets more and more detatched from the core atom, it becomes the well-known solvated electron in the bulk water [1].

One topic of our research is the lifetime of the lowest electronically excited state. Previous works in our group have shown, that the lifetimes strongly decreases for larger n [2]. For $n \geq 4$ they are on the order of 100 fs and lower. Similar results have been obtained for negatively charged pure water clusters [3, 4]. This short lifetimes are presumably provoked by fast internal conversion, which is strongly correlated to the DOS of the vibrons [2]. To resolve the lifetime for larger clusters $n \leq 20$ two colour pump-probe spectroscopy (800/ 400 nm) with 30 fs pulses has been used and will be discussed in this contribution.

[1] C.P. Schulz, C. Bobbert, T. Shimosato, K. Daigoku, N. Miura, K. Hashimoto, J. Chem. Phys. **119** (2003) 11620
[2] C.P. Schulz, A. Scholz, I.V. Hertel, Isr. J. Chem **44** (2004) 19
[3] J.R.R. Verlet, A.E. Bragg, A. Kammrath, O. Cheshnovski, D.M. Neumark, Science **307** (2005) 93
[4] A.E. Bragg, J.R.R. Verlet, A. Kammrath, O. Cheshnovski, D.M. Neumark, J. Am. Chem. Soc.**127** (2005) 15283

A 10.12 Di 16:30 Poster C3

Photoelectron spectroscopy of oxidized sodium clusters — •Kiran Majer and Bernd von Issendorff — Department of Physics, University of Freiburg, Stefan-Meier-Straße 21, 79104 Freiburg

The electronic structure of medium sized sodium dioxide clusters ($Na_nO_2^-$, n: number of sodium atoms) was investigated by photoelectron spectroscopy (PES). For cluster sizes containing up to 62 sodium atoms, the PES show comparable features (e.g. appearance of a new electronic shell) like for pure sodium clusters, but shifted in size by 4 sodium atoms towards bigger sizes. In the Jellium model picture, this can be explained by the localization of four electrons by the oxygen atoms.

This shift can not be found for bigger clusters with $n \geq 92$. In particular the electronic magic number 92 seems to be reached at the $Na_{93}O_2^-$ cluster, implying that the oxygen locates only 2 delocalized electrons.

The aim of the study was to find more information about the electronic and geometric structure of the oxidized cluster, as well as how it is influenced by the dopant.

A 10.13 Di 16:30 Poster C3

Clusters in Helium Droplets: Delaying the Coulomb Explosion in XFEL Pulses — •Christian Gnodtke, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden

In the context of atomic resolution, coherent diffractive imaging of non-periodic samples as suggested by Neutze et al. [1] we have simu-

lated the explosion dynamics of rare-gas clusters embedded in Helium droplets and exposed to an intense XFEL (X-Ray Free Electron Laser) pulse. We find that the Coulomb explosion of the sample, which is the main limiting factor for this imaging technique, is significantly delayed in comparison to the case without Helium. Using quantum-mechanical transition rates for K-shell photo-ionization and Auger-decay, which are the main damage processes, combined with a molecular dynamics simulation of free electrons and ions we calculate the laser-induced dynamics of Ar_N and Ne_N clusters, with N=55-500, and assess the decline of image quality with longer pulse lengths. We find that, embedded in a Helium droplet, the positive charge that builds up in the cluster through photo-ionization and Auger-decay is efficiently transferred to the Helium shell by ionization of the Helium atoms in the Coulomb field of the charged cluster. The Helium shell then explodes while the cluster ions are efficiently screened from each other by the electrons originating from the Helium droplet, thus enhancing the stability of the cluster and improving the overall image quality in an imaging experiment.

[1] R. Neutze et al., Nature **406**, 752 (2000)

A 10.14 Di 16:30 Poster C3

Elektronische Struktur endohedral dotierter Siliziumcluster aus resonanter Röntgenabsorptionsspektroskopie — •Philipp Klar[1], Konstantin Hirsch[1], Andreas Langenberg[1], Fabian Lofink[1], Robert Richter[1], Jochen Rittmann[1], Marlene Vogel[1], Vicente Zamudio-Bayer[1], Bernd von Issendorff[2], Thomas Möller[1] und Tobias Lau[1] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, Hardenbergstraße 36, D-10623 Berlin — [2]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg

Durch dotieren mit einem Übergangsmetallatom können Siliziumcluster in Käfigstrukturen stabilisiert werden. Um die Frage der Bindungsverhältnisse am Dotierungsatom zu klären, wurden VSi_n^+-Cluster elementspezifisch mit resonanter 2p-Röntgenabsorptionssektroskopie an der Synchrotronstrahlungsquelle BESSY untersucht. Dabei wurden die Cluster in einer Magnetronsputterquelle erzeugt und zur Spektroskopie in einer gekühlten Ionenfalle gespeichert. Es zeigt sich, dass das Dotierungsatom in einem magischen VSi_{16}^+-Cluster ein strukturreiches Röntgenabsorptionsspektrum besitzt, dass deutlich von dem des freien Ions abweicht. Die Spektren magischer und nichtmagischer endohedraler Siliziumcluster werden verglichen und daraus Rückschlüsse auf die elektronische Struktur gezogen.

A 11: Posters: Interaction with attosecond and VUV-light

Zeit: Dienstag 16:30–18:30 Raum: Poster C3

A 11.1 Di 16:30 Poster C3

Attosecond control of the electron position — •Paula Riviere, Camilo Ruiz, Andreas Becker, and Jan-Michael Rost — MPIPKS, Dresden

Attosecond pump-probe experiments are a promising tool for studying the structure and electron dynamics of atomic systems. With them, the control of ultrafast charge transfer between two nuclei in a dissociating molecule is possible. In this work we propose a theoretical scheme for such a process using realistic experimental parameters.

In this scheme, a pump-probe set of attosecond pulses is used to transfer charge between the two nuclei in a dissociative diatomic molecule (H_2^+, $r_0 \sim 40$ a.u.), The charge is initially located at one of the nuclei. The pump pulse can ionize the electron, which moves in the continuum until the probe pulse induces its reabsorption by the second nucleus, if the delay between the pulses is optimal.

We also propose a method for optimizing the absorption in the case of fixed delays, the usual experimental situation, by means of an infrared pulse, whose function is to accelerate or decelerate the electron as it covers the distance between the nuclei.

Finally, we present results for the case of an attosecond pulse train, in which the charge transfer is enhanced due to the consecutive effect of the different pulses.

Apart from the possibility of transferring charge between the nuclei, this process could also be useful to measure atomic distances.

A 11.2 Di 16:30 Poster C3

Pump-probe experiments combining an attosecond beamline with a reaction microscope — •Helga Rietz, Konstantinos Simeonidis, Ram Gopal, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, 69117 Heidelberg

The rapid development of femtosecond lasers over the last decade has enabled the investigation of nuclear dynamics in molecules in unprecedented detail. Recently, laser pulses of only 7 fs combined with advanced multi-particle momentum imaging spectrometers, so-called reaction microscopes, lead to the direct observation of the vibration of H_2 and D_2 molecules. However, electronic motion in atoms or molecules occurs on timescales of tens to hundreds of attoseconds and is thus not accessible with conventional ultra-fast laser technology, where the lasers' wavelength limits the pulse length to about 4 fs. Therefore we use high harmonic generation (HHG), which provides an efficient way to produce attosecond pulses.

Here we present the setup of a new experiment which combines an HHG light source with a reaction microscope. The light-source is based on a commercially available femtosecond laser system, delivering pulses with a length of 25 fs. Further compression to below 6 fs is achieved via filamentation. In order to guarantee highest stability and, at the same time enable utmost flexibility, the whole HHG setup is housed in one single vacuum chamber containing all necessary optics, a gas target for HHG and an XUV-spectrometer. In a first experiment we plan to characterize the attosecond pulses by 4π-detection of the photoelectrons in single ionization of helium.

A 11.3 Di 16:30 Poster C3

Transferioniation und komplexe Elektronendynamik in He^+-He-Stössen bei 60 keV/u — •Markus Schöffler[1], Jasmin Titze[1], Lothar Schmidt[1], Ottmar Jagutzki[1], Sebastian Otranto[2], Ron Olson[2], Horst Schmidt-Böcking[1] und Reinard Dörner[1] — [1]Johann Wolfgang Goethe-Universität, Frankfurt, Germany — [2]University of Missouri, Rolla, USA

Im Allgemeinen, und vor allem bei hohen Projektilgeschwindigkeiten (v_P ¿3 a. u.), ist die Dynamik einer Transferionisation, unabhängig vom genauen Projektilpotenzial. Dies gilt ebenso bei mittleren Projektilgeschwindigkeiten um v_P = 1,5 a. u., sofern es sich um nackte Projektilionen, wie H^+ bzw. He^{2+} handelt. Mittels der Technologie des Reaktionsmikroskops bzw. COLTRIMS (COLd Targe Recoil Ion Momentum Spectroscopy) wurde der Einfluss eines Projektilelektrons auf die Reaktionsdynamik kinematisch vollständig untersucht.

A 11.4 Di 16:30 Poster C3

Collision dynamic in transfer excitation processes revisited — •Markus Schöffler, Jasmin Titze, Hong-Keun Kim, Lothar Schmidt, Ottmar Jagutzki, Horst Schmidt-Böcking und Reinard Dörner — Johann Wolfgang Goethe-Universität, Frankfurt, Germany

We have measured the projectile scattering angle dependency for different final states for single electron capture in proton-helium collisions at an incident energy of 300 keV. With this fully differential data set we are able to get new insights in the dynamic of electron capture processes in combination with target or projectile excitation.

A 11.5 Di 16:30 Poster C3

DIRAC package – A new version to study interaction of the ions with the radiation field — •Andrey Surzhykov[1,2] and Stephan Fritzsche[1,3] — [1]Max–Planck–Institut für Kernphysik, Heidelberg — [2]École Normale Supérieure, Paris — [3]Gesellschaft für Schwerionenforschung (GSI), Darmstadt

During the last five years, the Dirac program has been found to be an efficient and reliable computer–algebraic tool for dealing with the Coulomb wave and Green's functions as well as their integrals [1, 2]. Owing to its user–friendly interface, this package became accessible not only to a few experts in relativistic atomic theory, but also to many scientists who have to deal with atoms and ions only occasionally. Here, we present an extension of the Dirac program for studying the interaction of the hydrogen–like ions with the radiation filed. In particular, the new Maple procedures support the symbolic as well as numerical evaluation of a whole variety of *bound–bound* transition properties including decay rates, angular distributions and polariza-

tion of characteristic radiation. Moreover, the revised version of the program also allows to investigate (radiative) *bound–free* as well as *free–bound* electron transitions as reflected by photoionization and radiative recombination, respectively.

[1] A. Surzhykov *et al.*, Comput. Phys. Commun. **165** (2005) 139.
[2] S. Fritzsche *et al.*, Nucl. Instr. Meth. B **235** (2005) 140.

A 11.6 Di 16:30 Poster C3

Laser-induced nuclear probing and excitation in muonic atoms — •Atif Shahbaz[1], Carsten Müller[1], Thomas J. Bürvenich[2], and Christoph H. Keitel[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Frankfurt Institute for Advanced Studies, Johann Wolfgang Goethe University, Ruth-Moufang-Str. 1, 60438 Frankfurt am Main

Muonic atoms represent a traditional tool for nuclear spectroscopy by applying atomic-physics techniques. In this contribution we consider a muonic atom exposed to a very strong laser field, where the muon becomes a dynamic probe of nuclear properties. We show that, as a consequence, effects of the finite nuclear mass and size are prominent in calculated high-order harmonic spectra from hydrogenlike muonic atoms [1]. The dependence of these effects on the laser parameters and the charge state of the binding nucleus is discussed [2]. The harmonic cutoff energies from muonic atoms can reach the MeV range, thus providing coherent γ-rays which could by applied to induce nuclear excitation.
[1] A. Shahbaz, C. Müller, A. Staudt, T.J. Bürvenich, and C.H. Keitel, PRL 98, 263901 (2007).
[2] A. Shahbaz, C. Müller, T.J. Bürvenich, and C.H. Keitel, in preparation.

A 11.7 Di 16:30 Poster C3

Two-photon induced double ionization of atoms at FLASH — •Moritz Kurka[1], Yuhai Jiang[1], Lutz Foucar[2], Artem Rudenko[1], Claus Dieter Schröter[1], Thorsten Ergler[1], Daniel Fischer[1], Jasmin Titzes[2], Till Jahnke[2], Markus Schöffler[2], Thorsten Weber[2], Reinhard Dörner[2], Alexander Dorn[1], Kai-Uwe Kühnel[1], Stefen Düsterer[3], Rolf Treusch[3], Michael Gensch[3], Sven Schössler[2], Tilo Havermeier[2], Mathias Smolarski[2], Kyra Cole[2], Robert Moshammer[1], and Joachim Ullrich[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Institut für Kernphysik, Universität Frankfurt, D 60486 Frankfurt — [3]DESY, Notkestrasse 85, 22607 Hamburg

Two-photon double ionization (TP-DI) bridges the gap between single- and multi-photon double ionization regimes and, thus, is of decisive importance to advance non-linear quantum theories, particularly for non-sequential absorption of two photons. Recently, the most intense VUV laser source world-wide became operational, the free electron laser at Hamburg (FLASH). It enables for the first time systematic studies of two-photon induced atomic and molecular fragmentation processes. In this poster, we will present very recent experimental results of recoil ion momentum distributions for the TP-DI of He and Ne at photon energies of 45 and 38 eV, respectively, as well as fully differential measurements for TP-DI of Ne at a photon energy of 45 eV employing the Heidelberg reaction microscope. These results, which might serve as benchmark data for theories, will be discussed in terms of electron emission pattern and possible double ionization mechanisms.

A 11.8 Di 16:30 Poster C3

Photoabsorbtion and Photoionization of Diatomic Molecules — •Irina Dumitriu and Alejandro Saenz — Humboldt-Universität zu Berlin, Institut für Physik, AG Moderne Optik, Hausvogteiplatz 5-7, D-10117, Berlin, Germany

The photoabsorbtion cross section of HeH^+ will be presented together with photoionization cross sections of the alkali dimer cations Li_2^+, Na_2^+, and $LiNa^+$. The latter have been calculated using two methods: a time-independent perturbative method and a time-dependent non-perturbative one. The photoabsorbtion of HeH^+ which is of interest for astrophysics and for the neutrino-mass experiments is currently drawing special attention because of the newly developed FEL experiment in Hamburg. The alkali dimer cations are presented as the first step to the photoionization of the alkali dimers, but they are also interesting in themselves since no *ab intio* data were available for their continuum spectra.

A 11.9 Di 16:30 Poster C3

Momentum-resolved photoemission of small atomic clusters — •Rainer Unterumsberger, Matthias Hoener, Sebastian Schorb, Heiko Thomas, Thomas Möller, and Christoph Bostedt — IOAP - Technische Universität Berlin

The investigation of photoionization and photofragmentation processes of rare-gas clusters with time-of-flight spectroscopy has lead to a rather detailed knowledge about their size-dependent electronic structure. However, comparably little is known about their angular photoemission characteristics. We have used a reaction microscopy akin COLTRIMS to investigate the photoemission of small to medium sized clusters in the near threshold regime. The photoelectrons could be detected in the full solid angle and their moment could be resolved. The data show that the photoemission of clusters becomes much more isotropic for increasing cluster sizes. The data is discussed and compared to recent angle-resolved tof experiments [Rolles, PRA 75, 031201 (2007)].

We would like to thank the groups of H. Schmidt-Böcking and R. Dörner from the Universität Frankfurt for their help.

A 12: Posters: Interaction with intense laser pulses

Zeit: Dienstag 16:30–18:30 Raum: Poster C3

A 12.1 Di 16:30 Poster C3

Laser-driven relativistic recollisions — •Markus C. Kohler[1], Michael Klaiber[1,2], Mario Verschl[1], Karen Z. Hatsagortsyan[1], and Christoph H. Keitel[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany — [2]Theoretische Quantendynamik, Physikalisches Institut der Albert-Ludwigs-Universität, Hermann-Herder-Straße 3, D-79104 Freiburg, Germany

In the relativistic regime the magnetically induced drift of an ionized electron severely suppresses the probability of the electron revisiting the ionic core and, consequently, the yield of harmonic photons. We discuss several methods to increase the efficiency of rescattering in the relativistic regime. In the strong relativistic regime, we show how efficient recollisions are feasible by employing strong laser pulses which are specially tailored as attosecond pulse trains. For experimental realization it is more advantageous to employ counter-propagating attosecond pulse trains. This way the energies of the revisiting electron at the atomic core can reach the MeV domain, thus rendering hard x-ray harmonics, zeptosecond pulses and nuclear reactions with single atoms feasible. Other recollision schemes proposed are based on two consecutive counterpropagating laser pulses and magnetic field.

A 12.2 Di 16:30 Poster C3

Angular resolved photoelectron spectra of H_2 in strong fields — •Timo Wilbois and Hanspeter Helm — Department of Molecular and Optical Physics, Stefan-Meier-Str. 19, 79104 Freiburg, Germany

We measured angular resolved photoelectron spectra and total ionisation rates of molecular hydrogen in strong laser fields at several wavelengths. Short pulses in the fs regime were used to ionise a thermal sample of H_2 in an imaging spectrometer. Electrons are detected by multichannel plates followed by a phosphor screen, which is photographed by a CCD camera. The angular resolved momentum distribution of the photoelectrons is retrieved by use of a backinversion algorithm [1].
In this work experimental results are presented, which can be used for comparison with available theoretical approaches [2,3].
[1] C. Bordas et al.: Rev. Sci. Instrum. **72**, 4084 (1996).
[2] H. Kono et al.: LPHYS 05, Kyoto Book of Abstracts (2005), 138.
M. Kanno et al.: Phys. Rev. A **72**, 033418 (2005).
[3] M. Awasthi, Y. V. Vanne, A. Saenz: J. Phys. B **38**, 3973 (2005).

A 12.3 Di 16:30 Poster C3

Photoelectron imaging spectroscopy of potassium atoms with polarization-shaped fs-laser pulses — •Marc Krug, Jens

Köhler, Matthias Wollenhaupt, and Thomas Baumert — Universität Kassel, Institut für Physik und Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), Heinrich-Plett-Str. 40, D-34132 Kassel, Germany

We present our new approach to use a photoelectron imaging spectrometer to measure two-dimensional projections of three-dimensional electron wave packets resulting from excitation of potassium atoms by polarization-shaped laser pulses. This resonant multi-photon ionization is very sensitive to the helicity of the used laser light and leads to different shapes of the outgoing electron wave packet. As a test experiment, we use an achromatic half-wave plate to rotate the polarization axis of the laser pulse and analyze the measured photoelectron distributions in a tomography-like way. Additionally a quarter-wave plate is used to create circularly polarized laser pulses. This strong-field excitation was recently discussed in terms of electric ring currents in atoms. We also make use of a Fourier transform polarization shaper which provides full control over the ellipticity of all spectral components in the pulse and measure angle-resolved photoelectron spectra of the shaped laser pulses. In the special cases of linearly and circularly polarized light excellent agreement between the two approaches is shown. However, employment of the pulse shaper opens up versatile possibilities to exert control on the atomic excitation by specifically designed laser pulses.

A 12.4 Di 16:30 Poster C3

Bound-free pair production in relativistic laser-ion collisions — •Carlus Deneke, Carsten Müller, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The process of electron-positron pair creation with capture of the electron into a bound state is considered in the relativistic collision of a nucleus with an intense x-ray laser beam. The production proceeds nonlinearly via few-photon absorption from the laser wave. The process probability is calculated within the strong-field approximation, and its dependence on the ion charge and energy as well as the laser intensity, frequency and polarization is studied.

A 12.5 Di 16:30 Poster C3

Coherent hard x-rays from attosecond pulse train-assisted harmonic generation — Michael Klaiber, •Hossein Ebadi, Carsten Müller, Karen Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

High-order harmonic generation from atomic systems is considered in the crossed fields of a relativistically strong infrared laser and a weak attosecond pulse train of soft x-rays. Due to one-photon ionization by the x-ray pulse, the ionized electron obtains a starting momentum that compensates the relativistic drift which is induced by the laser magnetic field, and allows the electron to efficiently emit harmonic radiation upon recombination with the atomic core in the relativistic regime. This way, short pulses of coherent hard x-rays of up to 40 keV energy can be generated.

A 12.6 Di 16:30 Poster C3

Coulomb Scattering in Strong Laser Fields — •Sebastian Bauch and Michael Bonitz — Christian-Albrechts-Universität Kiel, Institut für Theoretische Physik und Astrophysik, Leibnizstraße 15, 24098 Kiel, Germany

Generating fast electrons from table top sources powered by strong laser systems is becoming an interesting tool for experimentalists. In most cases the effect of the wake field acceleration is used [1]. In our present work, we show an alternative way to generate distributions of highly energetic electrons accelerated by strong laser fields where the main processes takes place on the nanometer scale. We solve the multi dimensional time dependent Schrödinger equation on large spatial grids and show how electron wave packet scattering on Coulomb-like potentials (ions) in strong laser fields leads to resonance phenomena and distributions of fast electrons. In previous works [2] only one dimensional systems have been studied. We now demonstrate that carefully chosen scattering geometries and additional external electric fields allow to extend these results to realistic setups. In order to make predictions the angular resolved energy spectrum is analyzed.

[1] Th. Katsouleas, Nature 2004, Vol. 341 p. 516
[2] H.J. Kull and V.T. Tikhonchuk, Phys. Plas. **12,** 063301 (2005)

A 12.7 Di 16:30 Poster C3

Bestimmung und Optimierung der Zeitauflösung von MCP-Detektoren — •Jörg Voigtsberger, Achim Czasch und Ottmar Jagutzki — Institut für Kernphysik, Johann Wolfgang Goethe-Universtität, Frankfurt (Main), Germany

Durch Fokussierung eines Laserstrahls wird an Luft ein Plasma erzeugt. Hierbei entsteht Strahlung höherer Ordnung im UV-Bereich, welche mit einem MCP-Detektor nachgewiesen werden kann. Mit Hilfe eines Harmonic Seperators werden die UV-Photonen vom Laser-IR-Licht getrennt und auf den MCP-Detektor geleitet, wo sie Signale erzeugen. Über eine Referenzmessung mit einer Photodiode kann so die Zeitauflösung des Detektors bestimmt werden. Da die so erzeugten Signale immer identisch sind, kann nun über verschiedene Einstellungen und Modifikationen am Detektor deren Wirkung auf die Zeitauflösung beobachtet werden.

A 12.8 Di 16:30 Poster C3

Ein gepulstes Überschall Gasjet-Target für hoch auflösende Rückstoßionen Impulsspektroskopie — •Andreas Achtelik, Karl Zrost, Artem Rudenko, Kai-Uwe Kühnel, Robert Moshammer und Joachim Ullrich — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

Die Rückstoßionen Impulsspektroskopie hat sich, insbesondere in Kombination mit effizienten Elektronen-Spektrometern (so genannte Reaktions-Mikroskope oder COLTRIMS Spektrometer), als ein mächtiges Werkzeug zur Untersuchung von atomaren und molekularen Reaktionen etabliert. Die hierbei erreichbare Auflösung ist in den meisten Fällen durch die anfängliche Impulsunschärfe der Target-Atome begrenzt. Zwar können kalte Atome in einer MOT-Falle als Target verwendet werden (MOTRIMS), das ist bisher aber nur mit Alkali-Atomen möglich. Bei dem hier beschrittenen Weg entfällt diese Restriktion, allerdings wird ein gepulster Projektilstrahl benötigt. Durch Pulsung des Atomstrahls mit Hilfe eines schnell drehenden Chopper-Rades (30000 U/min) und Synchronisation mit den Projektil-Pulsen ist es möglich eine bestimmte Geschwindigkeitsklasse aus dem Atomstrahl *herauszuschneiden*. Die effektive Impulsauflösung lässt sich dadurch drastisch erhöhen. Das Prinzip der Atomstrahl-Pulsung wird erläutert und erste Ergebnisse zur Ionisation von Atomen in intensiven Laserfeldern werden vorgestellt.

A 12.9 Di 16:30 Poster C3

Formation of H_2^+ in laser-induced fragmentation of CH_4 — •Bettina Fischer, Ulrich Wiedemann, Artem Rudenko, Manuel Kremer, Thorsten Ergler, Karl Zrost, Bernold Feuerstein, Andreas Achtelik, Claus Dieter Schröter, Robert Moshammer, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Heidelberg

Three-dimensional coincident momentum spectroscopy is used to study the molecular fragmentation dynamics of CH_4. Therefore the CH_4 molecules have been exposed to linear polarized intense ($3 * 10^{14} W/cm^2$) short ($9fs$) laser pulses while the outcoming ions and electrons were detected by using a "Reaction Microscope"

Single-shot as well as pump-probe experiments have been performed both showing a noticable amount of H_2^+ ions in the timo-of-flight spectra.

By analyzing the coincident ion spectra we found out that H_2^+ ions originate from the channel $CH_4 \rightarrow CH_2^+ + H_2^+ + 2e^-$. Thus, the formation of an $H - H$ bond occurs on the time scale of the laser pulses, e.g. within a few femtoseconds.

A 12.10 Di 16:30 Poster C3

Zeitaufgelöste zwei-Farben Streuexperimente am FLASH - FEL — •Marcus Adolph[1], Daniela Rupp[1], Heiko Thomas[1], Matthias Hoener[1], Hubertus Wabnitz[2], Rolf Treusch[2], Christoph Bostedt[1] und Thomas Möller[1] — [1]IOAP - Technische Universität Berlin — [2]Hasylab at DESY

Mittels intensiver Röntgenstrahlung von Freie-Elektronen Lasern sollen in Zukunft molekulare Strukturen mittels Einzelschuss-Streuexperimenten untersucht werden. Allerdings gibt es über die Dynamik von Materie in hochintensiven Röntgenlaserpulsen noch keine experimentellen Erkenntnisse. Der FLASH - FEL am DESY in Hamburg bietet erstmals die Möglichkeit solche Untersuchungen im weichen Röntgenbereich durchzuführen. Wir entwickeln ein Experiment für zeitaufgelöste Einzelschuss-Streuexperimente an Clustern mit Größen im Limit der zur Verfügung stehenden Wellenlänge von 13 nm. Hierfür verwenden wir zwei Multilayer-Spiegel, die die erste (Pump) und dritte (Probe) Harmonische des FEL in die Wechselwirkungszone fokussieren. Durch einen Weglängenunterschied im Spiegel kann ein zeitlicher

Versatz der Pump und Probe Pulse eingestellt werden. Als Detektor verwenden wir eine energiedispersive CCD des MPI - Halbleiterlabors. Erste Ergebnisse werden vorgestellt und zukünftige Optionen für Pump - Probe Experimente am FLASH diskutiert.

A 12.11 Di 16:30 Poster C3

Ionization of molecular hydrogen in intense ultrashort laser pulses: orientational dependence — Yulian Vanne and •Alejandro Saenz — AG Moderne Optik, Institut für Physik, Humboldt-Universität zu Berlin, Hausvogteiplatz 5-7, 10117 Berlin, Germany

The full ab initio treatment of the ionization process of molecular hydrogen in strong laser field remains a challenge for theory. For linear polarized laser pulses the complexity of the problem depends on the orientation of molecule with respect to molecular axis. Whereas the simplest case of parallel orientation has recently been discussed in literature, there exist no data for the more complicated case of a perpendicular orientation.

In the present work we demonstrate first results obtained for the case of perpendicular orientation based on the method described in [1]. We compare the ionization yield for parallel and perpendicular orientation for different internuclear distances and laser pulses.

[1] M. Awasthi *et al.*, J. Phys. B **38**, 3973 (2005)

A 12.12 Di 16:30 Poster C3

Laser-induced ionization of diatomic molecules studied by an extension of the Basis Generator Method — •Luis F. Menchero and Tom Kirchner — Institüt für Theoretische Physik, TU-Clausthal. Leibnizstraße 10. D-37678 Clausthal-Zellerfeld. Germany.

In this work we extend the Basis Generator Method (BGM), described by Lüdde et al J. Phys. B.: At. Mol. Opt. Phys. **29**, 4423 (1996) to the interaction between a diatomic molecule and a laser pulse. The obtained Extended Two Center (XTC-) BGM is practical to calculate the ionization probabilities with a relatively small set of functions, since the included basis states are constructed such as to minimize couplings to that part of Hilbert space which is not spanned.

Our aim ist twofold: Firstly, we have checked the validity of the XTC-BGM by applying it to the one-electron $(HeH)^{2+}$ quasimolecule in a short, strong field. Secondly, the approach can be easily generalized to many-electron molecules within a single-active electron model. First results will be presented at the conference.

A 12.13 Di 16:30 Poster C3

Correlated Two-Electron Momentum Spectra for Strong-Field Non-Sequential Double Ionization — Artem Rudenko[1], Vitor de Jesus[2], •Thorsten Ergler[1], Karl Zrost[1], Bernold Feuerstein[1], Manuel Kremer[1], Bettina Fischer[1], Claus Dieter Schröter[1], Robert Moshammer[1], and Joachim Ullrich[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Centro Federal de Educação Tecnológica de Química de Nilópolis/RJ, Rio de Janeiro, Brazil

Non-sequential double ionization (NSDI) of atoms by intense linearly polarized laser fields has remained one of the central and most controversial topics in strong-field physics for more than two decades. Though most of the experimental findings are in good overall agreement with a semiclassical "recollision" model, the current understanding of NSDI is far from being complete. Here we present the results of a kinematically complete experiment on NSDI of He by 800 nm 25 fs 1.5 PW/cm^2 laser pulses. In contrast to earlier experimental results for Ne and Ar, we observe a pronounced v-shaped structure in the two-electron momentum distributions along the laser polarization ("longitudinal") direction, which was predicted by several S-matrix calculations, and by the numerical solutions of the time-dependent Schrödinger equation. This pattern, indicating that both electrons have non-equal longitudinal momenta in the final state, can be explained by the role of the Coulomb repulsion and typical (e,2e) recollision kinematics.

A 12.14 Di 16:30 Poster C3

Double-Slit Light Diffraction in Strong Electromagnetic Fields — •Ben King, Antonino Di Piazza, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

In [1] the vacuum-polarisation effects of change in ellipticity and polarisation of a laser probe beam passing through an ultra-intense standing wave, were calculated. We further develop these results to increase the measurable polarisation and ellipticity, by calculating diffraction effects from the double-slit-like setup of two parallel and off-centre, gaussianly-focused, strong field waves propagating against each other. We move towards a measurable set-up through calculations of the off-axis effects on a focused probe beam, allowing alternative detection of these vacuum effects.

[1] A. Di Piazza, K. Z. Hatsagortsyan, and C. H. Keitel, Phys. Rev. Lett. 97, 083603 (2006)

A 12.15 Di 16:30 Poster C3

Multiphoton ionization of laser cooled lithium — •Michael Schuricke, Ganjun Zhu, Johannes Albrecht, Jochen Steinmann, Konstantinos Simeonidis, Alexander Dorn, and Joachim Ullrich — Max Plank Institut für Kernphysik, 69117 Heidelberg, Germany

Being the most fundamental three electron system, lithium is of particular interest for both theoretical and experimental investigations on quantum-dynamical few-body processes. In order to make lithium accessible to kinematically complete measurements of atomic fragmentation by particle or photon impact, a magneto-optical trap (MOT) has been combined for the first time with a so called reaction microscope. Since the reaction microscope has the capability of coincident measurements of the full vector momenta of all charged fragments, the electrons as well as the residual ion, and the MOT provides an ultracold target of atomic lithium in the sub-mK regime, highly resolved momentum spectra can be obtained. Besides, ionization can be examined both from the ground and exited states.

As a first step, multiphoton ionization of lithium in intense laser fields, using 30 fs pulses at 800 nm wavelength from a Ti:Sa fs-laser system was studied. Here, angle- and energy resolved ion- and electron-spectra, taken at intensities between 10^{11} and 10^{14} W/cm^2, are presented.

Future experiments will include double ionization in intense fields, single photon double ionization at FLASH and studies of electron impact ionization of lithium in prepared states.

A 12.16 Di 16:30 Poster C3

Experiments on Strong Field Photodetachment — •Boris Bergues, Hanspeter Helm, and Igor Yu. Kiyan — Physikalisches Institut, Universität Freiburg, Stefan-Meier-Str. 19, Freiburg, Germany.

We present experimental studies of the photodetachment process in negative ions subjected to a strong laser field. A negative ion represents an atomic system where the outer electron is bound to the atomic core by a short-range potential. Therefore, negative ions are best suited to verify predictions of Keldysh-like theories, where the electron interaction with the core is neglected in the description of the final continuum state. In our experiments we measure the angle resolved momentum distributions of the photoelectrons ejected from negative ions in laser fields with a peak intensity reaching 5×10^{14} W/cm^2. Under such strong field conditions the electron yield at high kinetic energies is found to be due to the process of sequential double detachment. In the present work we investigate this process for different ions having various ratio of electron affinity to ionization potential. In particular, experiments are performed on Br^-, F^- and H^-. The measured spectra are compared with the predictions of the strong field approximation. The effect of core polarization in the sequential photodetachment is discussed.

A 12.17 Di 16:30 Poster C3

Complete Characterization of Molecular Dynamics in Ultrashort Laser Fields — •Bernold Feuerstein[1], Thorsten Ergler[1,2], Artem Rudenko[1], Thomas Niederhausen[3], Bettina Fischer[1], Manuel Kremer[1], Claus Dieter Schröter[1], Robert Moshammer[1], Uwe Thumm[3], and Joachim Ullrich[1] — [1]Max-Planck-Institut für Kernphysik, D-69029 Heidelberg, Germany — [2]Present address: ICFO - The Institute of Photonic Sciences, Mediterranean Technology Park, Av Canal Olimpic s/n, 08860 Castelldefels (Barcelona), Spain — [3]James R. Macdonald Laboratory, Kansas State University, Manhattan, Kansas 66506-2604, USA

Reaction Microscope-based, complete and time-resolved Coulomb explosion imaging of vibrating and dissociating D_2^+ molecules with femtosecond time-resolution allowed us to perform an inter-nuclear distance (R-)dependent Fourier analysis of the corresponding wave-packets. Calculations demonstrate that the obtained two-dimensional R-dependent frequency spectra enable the complete characterization of the wave-packet dynamics and directly visualize the field-modified molecular potential curves in intense, ultrashort laser pulses.

A 12.18 Di 16:30 Poster C3

Anregung atomarer Systeme in starken Laserfeldern — •Karsten Gorling[1], Thomas Nubbemeyer[1], Alejandro Saenz[3], Ulli Eichmann[1,2] und Wolfgang Sandner[1,2] — [1]Max-Born-Institut , Max Born Str. 2a, 12489 Berlin — [2]Institut für Optik und atomare Physik, TU Berlin — [3]AG Moderne Optik, Institut für Physik, Humboldt-Universität zu Berlin

Bei der Wechselwirkung intensiver Laserfelder mit Atomen und Molekülen stellt die Anregung neutraler Zustände neben den bekannten Prozessen der Harmonischen Erzeugung, nichtsequentieller Mehrfachionisation und Above Threshold Ionisation einen bislang wenig untersuchten, aber bedeutenden weiteren Prozess dar. Ein kleiner Anteil der angeregten Atome bzw. Moleküle zerfällt typischerweise in langlebige metastabile Zustände. Thermische Atome in solchen angeregten Zuständen können direkt in einem Multi-Channel Plate Detektor nachgewiesen werden.

Wir stellen Messungen vor, in denen mit diesem Nachweisverfahren verschiedene atomare und molekulare Gase in intensiven Laserfeldern untersucht werden, um Rückschlüsse auf die zu Grunde liegende Dynamik zu erhalten. Darüber hinaus wird untersucht, in wie weit mit der Nachweismethode Aussagen über die Geschwindigkeitsverteilung von Gasen getroffen werden kann sowie Strahleigenschaften des intensiven Lasers charakterisiert werden können.

A 12.19 Di 16:30 Poster C3

Level shifts of highly charged ions in laser fields — •O. Postavaru, Z. Harman, and C. H. Keitel — Max-Planck-Institut für Kernphysik

We investigate the level structure of heavy hydrogenlike ions in laser beams. In heavy ions, the electrons are tightly bound by the Coulomb potential of the nucleus, which prohibits ionization even by strong lasers. However, interaction with the light field leads to dynamic shifts of the electronic energy levels. We apply a fully relativistic description of the electronic states by means of the Dirac equation. Interaction with the monofrequent laser field is treated by second-order time-dependent perturbation theory. Our formalism goes beyond the Stark dipole approximation and takes into account the non-dipole effects of retardation and interaction with the magnetic field components of the laser beam. The resulting level shifts are relevant for experiments with multiply charged ions at present and near-future laser systems like the FLASH [1] and the PHELIX [2] facilities. [1] S.W. Epp, J.R. Crespo López-Urrutia, G. Brenner *et al.*, Phys. Rev. Lett. 98, 183001 (2007) [2] P. Neumayer, R. Bock, S. Borneis *et al.*, Laser and Particle Beams 23, 385 (2005)

A 13: Posters: Photoionization and atomic systems in external fields

Zeit: Dienstag 16:30–18:30 Raum: Poster C3

A 13.1 Di 16:30 Poster C3

Photoionization of highly charged ions — •Martin C. Simon, Sascha W. Epp, Thomas M. Baumann, José R. Crespo López-Urrutia, and Joachim Ullrich — Max-Planck Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany

Photoionization counts to the essential processes of light-matter interaction. For such experiments sufficiently high photon flux and target densities have to be provided. While cross-sections for atoms were already measured during the middle of the last century, the first measurements on singly charged ions started only about two decades ago. There are a few results on multiply chared ions but so far HCIs (highly charged ions) could not be studied. In principle an EBIT (electron beam ion trap) can provide a sufficiently high HCI density but the required photon energies increase strongly with the charge state of the ion. Combined with the demand of high flux this type of experiments are restricted to modern light sources like fourth-generation synchrotrons and soft X-ray FELs (free electron lasers). With a transportable cryogenic EBIT it was recently possible for the first time to perform resonant laser spectroscopy on highly charged iron ions at the FEL in Hamburg (S. W. Epp et al. PRL 98). This EBIT is now equipped with an extraction system in order to measure photoionization by the detection of extracted ions. First tests will be performed at the FEL in Hamburg in March 2008 and further studies will take place at the Berliner electron storage ring synchrotron BESSY in June 2008.

A 13.2 Di 16:30 Poster C3

An approximate quantum number in doubly excited helium — •Ralph Püttner[1], Jiang Yuhai[1,2], Dominique Delande[3], Michael Martins[4], and Günter Kaindl[1] — [1]Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14,14195 Berlin, Germany — [2]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [3]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [4]Laboratoire Kastler-Brossel, Université Pierre et Marie Curie-Paris 6, ENS, CNRS; 4 Place Jussieu, F-75005 Paris, France

Helium close to the double ionization threshold is a prototypical system for studying quantum chaos. In this contribution experimental and theoretical total photoionization cross sections of doubly excited He up to the single ionization threshold I_{15} of He^+ are presented, revealing excellent agreement. All spectra are dominated by principal Rydberg series, what is explained by the observation that the quantity $F = N - K$ is approximately a good quantum number for a large fraction of states. The statistical distributions of nearest-neighbor energy spacings between resonances of Rydberg series with small F approach a Wigner distribution. The results show no indication for a transition to full chaos – i.e. a loss of all approximate quantum numbers – in He. From these results we derive a lower limit for the appearance of Eriscon fluctuations, which are also expected directly below the double ionization threshold.

A 13.3 Di 16:30 Poster C3

Enhanced Four-Wave Mixing in mercury isotopes, prepared by Stark-chirped rapid adiabatic passage — •martin oberst, jens klein, and thomas halfmann — TU darmstadt, starße xy 204777777

We demonstrate significant enhancement of four-wave mixing (FWM)in coherently driven mercury isotopes to generate vacuum-ultraviolet radiation at 125 nm. The enhancement is accomplished by preparation of the mercury atoms in a state of maximum coherence, i.e. maximum nonlinear-optical polarization, driven by Stark-chirped rapid adiabatic passage (SCRAP). In this technique a pump laser at 313 nm excites the two-photon transition between the ground state $6s^2\ ^1S_0$ and the target state $7s\ ^1S_0$ in mercury. A strong, off-resonant radiation field at 1064 nm generates dynamic Stark shifts. These Stark shifts induce a rapid adiabatic passage process on the two-photon transition. The maximum nonlinear-optical polarization induced by SCRAP permits efficient FWM of the pump laser and an additional probe laser at 626 nm. The efficiency is further enhanced, as the SCRAP process stimulates the *complete* set of different mercury isotopes to participate in the FWM-process. This enlarges the effective atomic density of the medium. Thus, we observe the generation of radiation at 125 nm enhanced by more than one order of magnitude with respect to conventional frequency conversion. Parallel to the FWM-process, we monitored the evolution of the population in the medium by laser-induced fluorescence. These data demonstrate efficient coherent population transfer by SCRAP.

A 13.4 Di 16:30 Poster C3

Visible spectra of highly charged ions: g-factor and hyperfine splitting — •José R. Crespo López-Urrutia, Monika Binder, Lodewijk Arntzen, Volkhard Mäckel, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, 69117 Heidelberg

The lines present in the visible spectra of highly charged ions (HCI) can display large hyperfine splittings due to the large overlap between the wave functions of the optical electron and of the nucleus. The strong magnetic field present in an electron beam ion trap allows to investigate and compare the simultaneous effects of the internal (nuclear magnetic moment) and external field. A high resolution optical spectrometer is used to register the emission spectra of highly charged Bi and Xe ions having non-zero nuclear spins. By evaporatively cooling the trapped ions, the Zeeman and hyperfine components of M1 transitions within the ground state configuration of Ti-like ions can be resolved.

A 13.5 Di 16:30 Poster C3

EBIS test ion source for HITRAP and charge breeding — Sabrina Geyer[1], Oliver Kester[1], Jochen Pfister[2], Alexey Sokolov[1], Thomas Stoehlker[1,3], and •Gleb Vorobjev[1] — [1]Gesellschaft für Schwerionenforschung — [2]Universität Frankfurt, Institut für Angewandte Physik — [3]Universität Heidelberg, Fakultät für Physik und Astronomie

The electron beam ion source MAXEBIS from Frankfurt University has been installed in a test beam setup at GSI to deliver highly charged ions for HITRAP and to serve for charge state breeding experiments. Recent experiments were dedicated to evaluate the parameters of the ion beam line, i.e. emittance, dependence of the charge state distribution on the confinement time in the electron beam and the resolution of multi passage spectrometer (MPS). Simulations of the beam-line using SIMION 7.0 were performed add additional elements were installed in order to improve the beam current for more efficient ion transfer. To simplify downstream focusing the setup has been equipped with new diagnostics and beam optics devices. Due to the complicate running procedure of the cryogenic MAXEBIS a next generation compact Dresden electron beam ion trap (EBIT) has been purchased and installed at GSI and will be used for the routine operation. The EBIT will continue the experiments done so far with the MAXEBIS and is dedicated as SPARC test ion source. For ion - neutral atom collision experiments a Magnesium jet target will be mounted. X-ray spectroscopy will allow the investigation of processes of the slow ions - fast electrons interaction in the ionization chamber.

A 13.6 Di 16:30 Poster C3

Resonant strong field ionization of atomic hydrogen — •Mircea G. Girju, Kiril Hristov, Oleg Kidun, and Dieter Bauer — Max Planck Institute for Nuclear Physics, Heidelberg, Germany

In H(1s) close to resonance with the 2p state Autler-Townes duplets are known to appear in the photoelectron spectra [1]. In the case of sufficiently weak laser fields the two peaks of each Autler-Townes pair are separated by $\Omega = \sqrt{\Omega_{\mathrm{R}}^2 + \Delta^2}$ with Ω_{R} the Rabi-frequency and Δ the detuning. However, our numerical *ab initio* solutions of the time-dependent Schrödinger (TDSE) equation show that already at $10^{14}\,\mathrm{Wcm}^{-2}$ the true peak separation deviates from the naively expected gap according to the above formula. The reasons for this failure are the use of the rotating wave approximation and the neglect of ionization, AC Stark effect, and other excited states.

A strong field approximation (SFA) is developed for an initially bound electron interacting with a resonant high-frequency pulse causing both Rabi-floppings and ionization. Taking the pure Rabi-flopping as the zeroth-order approximation in a straightforward two bound state-SFA turns out to yield inaccurate Autler-Townes peak strengths, the more so the larger the detuning $|\Delta|$ is [2].

[1] K.J. LaGattuta, Phys. Rev. A **47**, 1560 (1993).
[2] M.G. Girju, K. Hristov, O. Kidun, and D. Bauer, J. Phys. B: At. Mol. Opt. Phys. **40**, 4165 (2007).

A 13.7 Di 16:30 Poster C3

Entwicklung einer Pepperpot-Emittanzmessanlage und Messungen zur Inbetriebnahme des HITRAP Linearbeschleunigers — •Jochen Pfister[1,2], Oliver Kester[2] und Ulrich Ratzinger[1] für die HITRAP-Kollaboration — [1]Universität Frankfurt, Institut für Angewandte Physik, Max-von-Laue-Str. 1, 60438 Frankfurt — [2]Gesellschaft für Schwerionenforschung, Planckstr. 1, 64291 Darmstadt

Die erste Stufe des HITRAP-Beschleunigers, die Resonatoren des Double-Drift-Bunchers, wurden in zwei Strahlzeiten im Mai und August 2007 in Betrieb genommen. Dabei gehörten u.a. die Emittanzmessungen zum angestrebten Messprogramm.

Eine Repetitionsrate von einem Ionenbunch in einer Minute aus dem ESR schloss die Schlitz-Gitter-Methode zur Bestimmung der Emittanz aus. Daher wurden Messungen mit einer Pepperpot-Anlage sowie die Berechnung der Emittanz aus Strahlprofilmessungen durchgeführt.

Es werden die Messmethoden und Auswertealgorithmen sowie die Ergebnisse aus beiden Strahlzeiten dargestellt und mit den Designwerten verglichen. Außerdem wird die Entwicklung einer Pepperpot-Emittanzmessanlage auf der Basis eines Micro-Channel-Plates vorgestellt.

A 13.8 Di 16:30 Poster C3

Calculation of Berry phases emerging in atomic beam spin echo experiments — •Martin-Isbjörn Trappe, Thomas Gasenzer, and Otto Nachtmann — Institut für Theoretische Physik, Philosophenweg 16, 69120 Heidelberg

We consider the derivation of geometrical phase factors in longitudinal atomic beam spin echo (lABSE) experiments. The propagation of hydrogen like atoms in stationary electric and magnetic fields leads to geometrical phases in addition to the common dynamical phase factors. We provide numerical calculations of parity conserving as well as parity violating contributions to the geometrical phases depending on the electromagnetic field configuration and the initial superposition of the atomic eigenstates. The conditions for suitable configurations of lABSE experiments for measuring Berry phases in hydrogen are investigated.

A 14: Posters: Interaction of matter with ions

Zeit: Dienstag 16:30–18:30 Raum: Poster C3

A 14.1 Di 16:30 Poster C3

Szintillationslicht hochgeladener Ionen niedriger Energie — •Manuel Vogel, Oliver Kester und Danyal F. A. Winters — Gesellschaft für Schwerionenforschung GSI, Planckstrasse 1, 64291 Darmstadt

Wir präsentieren systematische Messungen der Intensität des Szintillationslichts, welches niederenergetische, hochgeladene Ionen in anorganischen Szintillatoren erzeugen. Hierzu wurden ladungsselektierte Strahlen aus Xenon-Ionen Xe^{q+} $(3 \leq q \leq 18)$ auf Leuchtschirme gerichtet und die Intensität des erzeugten Szintillationslichts mittels einer CCD-Kamera gemessen. Wir zeigen die Abhängigkeit der Lichtintensität von Strahlparametern wie Stromdichte und Energie, insbesondere untersuchen wir erstmals explizit die Abhängigkeit vom Ladungszustand der Ionen. Die hier untersuchten Ionenstöme liegen zwischen 1 und 100 nA bei Ionenenergien zwischen 5 und 17,5 keV/q, und damit in einem Bereich wie er unter anderem für Untersuchungen und Strahldiagnose im Rahmen des HITRAP-Projektes and der GSI, Darmstadt, relevant ist.

A 14.2 Di 16:30 Poster C3

Orientierungseffekte bei der stossinduzierten Mehrfachionisation von Acetylen — •Udo Werner[1], Bärbel Siegmann[2] und Nikolai Kabachnik[1] — [1]Fakultät für Physik, Universität Bielefeld, 33615 Bielefeld — [2]Fakultät für Physik, Technische Universität Dortmund, 44221 Dortmund

Die Mehrfachionisation und Fragmentation von C_2H_2 wurde in Stössen mit 100–300 keV H^+ und He^+ Ionen untersucht. Die im Stoss erzeugten Elektronen und Ionen werden durch ein homogenes elektrisches Feld separiert und mit einem orts- und zeitauflösenden Multi-Hit-Detektor nachgewiesen, der die koinzidente Messung der Impulsvektoren korrelierter Fragmentionen erlaubt. Hierdurch kann die Kinematik einzelner Fragmentationskanäle, wie z.B. $C_2H_2 \rightarrow CH^+ + CH^+$ oder $C_2H_2 \rightarrow H^+ + C^+ + C^+ + H^+$, vollständig analysiert werden, wodurch neben der Bestimmung von relativen Wirkungsquerschnitten auch die Analyse von Winkelkorrelationen und der kinetischen Energien der Fragmentionen möglich wird. Da es sich bei Acetylen um ein lineares Molekül handelt, kann aus diesen Informationen insbesondere die Orientierung der Molekülachse relativ zur Projektilrichtung während des Stosses rekonstruiert werden. Bei einigen Fragmentationskanälen zeigen die Wirkungsquerschnitte eine deutliche Orientierungsabhängigkeit. Die Ergebnisse werden mit den Vorhersagen eines statistischen Energiedepositionsmodells [1] verglichen.

[1] B. Siegmann, et. al., Phys. Rev. A65, 010704 (2001)

A 14.3 Di 16:30 Poster C3

Investigation of multiple charge transfer using MOTRIMS — •Ina Blank[1], Simone Götz[1], Terry Mullins[1], Wenzel Salzmann[1], Roland Wester[1], Matthias Weidemüller[1], Gabriel Hasan[2],

Reinhard Morgenstern[2], Ronnie Hoekstra[2], Alexey Sokolov[3], and Wolfgang Quint[3] — [1]Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str.3, 79104 Freiburg, Germany — [2]KVI, Atomic Physics, Zernikelaan 25, NL-9747 AA Groningen, The Netherlands — [3]GSI mbH, Planck Str.1, D-64291 Darmstadt, Germany

We plan to investigate coherence effects in multiple charge transfer between neutral atoms and highly charged ions. A transportable high density dark SPOT [1] for Rb atoms, equipped with a recoil ion momentum spectroscopy (RIMS) detector [2] will be used in conjunction with the highly charged ion beam facilities at the GSI in Darmstadt. The low initial momentum of the atoms allows one to sensitively measure momentum changes. We present details of the experimental setup.

In a recent experiment performed at the KVI, Groningen, the energy dependence of double electron transfer from laser-cooled Na to O^{6+} was measured. The results will be presented and compared with model predictions.

[1] C. Townsend et al., PRA 53, 1702 (1996)
[2] J. Ullrich et al. J. Phys. B 30, 2917 (1997)

A 14.4 Di 16:30 Poster C3

Design of a multi-purpose ion beam deceleration station for slow ion-surface interaction and ion-atom collision studies — •Rainer Ginzel[1], Martin C. Simon[1], Walter Meissl[2], José R. Crespo López Urrutia[1], and Joachim Ullrich[1] — [1]Max-Planck-Institut für Kernphysik, D-69029 Heidelberg, Germany — [2]Institut für Allgemeine Physik, Technische Universität Wien, A-1040 Wien, Austria

Improvements of the beam line optics at the Heidelberg electron beam ion trap (EBIT) have led to an enhancement of the ion extraction efficiency. To take advantage of this development, different types of experiments in the low energy regime are planned. In order to study the interaction of highly charged ions with surfaces or gas targets at low kinetic energies, it is of importance to provide a slow monoenergetic and well focused ion beam with small angular divergence. Therefore, a multi-purpose ion beam deceleration station has been designed which is suitable for both types of work. Its ion optical properties were investigated by means of a numerical simulation, and the design was optimized to meet the mentioned requirements best.

A 14.5 Di 16:30 Poster C3

Two Center Cnterference in Collisions between H_2^+ and He — •Shaofeng Zhang[1,3], Jan Suske[1], Daniel Fischer[4], Kai-Uwe Kuehnel[1], Siegbert Hagmann[2], Andreas Krauss[1], Robert Moshammer[1], and Joachim Ullrich[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, German — [2]Gesellschaft für Schwerionenforschung, Planckstr. 1,64291 Darmstadt, Germany — [3]Institute of Modern Physics, CAS, Lanzhou 730000, China — [4]Stockholm University, AlbaNova University Centre, 10691 Stockholm, Sweden

Two-center interference effects in collisions of fast ions with H_2 molecules have been intensively studied both theoretically(e.g.[1]) and experimentally(e.g.[2]). We investigated in a kinematically complete experiment the ionization of a neutral He target in collisions with H_2^+-molecular ions at 0.5 and 1 MeV. The momenta of the recoiling He ions and the electrons produced in the collisions were measured using a "Reaction Microscope"[3]. The fragments of the H_2^+ were separated by a dipole magnet after the interaction region and detected by two position sensitive MCP detectors. From this information the orientation and internuclear distance of the molecular ion at the instant of the collision could be determined. We will report on the appearance of interference effects in the differential data which should arise due to the two centers potential of the molecular projectile.

[1] S. E. Corchs et al., Nucl. Instrum. Methods Phys. Res., Sect. B 149, 247 (1999). [2] N. Stolterfoht et al., Phys. Rev. Lett. 87, 023201 (2001). [3] Ullrich et al., Rep. Prog. Phys. 66, 1463 (2003)

A 14.6 Di 16:30 Poster C3

Cross sections for antiproton collisions — •Armin Lühr and Alejandro Saenz — Humboldt-Universität zu Berlin, Institut für Physik, Moderne Optik, Hausvogteiplatz 5-7, D-10117 Berlin

In the near future the conditions for the production of slow antiproton beams will strongly improve with the upcoming low energy antiproton facility FLAIR at the GSI Darmstadt. This provides on the one hand the basis for fundamental physics like tests of the CPT-invariance or gravity of antimater. However, under these conditions investigations of antiproton collisions at energies below the applicability of the first Born approximation will also be possible. Therefore, new impetus is given to theoretical investigations dealing with slow antiproton collisions. The calculations should in turn also be useful for the design of the new experimental facility where, e.g., the interaction of antiprotons with residual-gas atoms is important.

Theoretical investigations for collisions of the alkali metal atoms Li, Na and K with antiprotons in an energy range from 0.2 to 1000 keV have been performed. Cross sections for excitation, ionization and angular resolved ionization are presented. The calculations are based on a time-dependent close coupling method. The valence electron is treated explicitly while the closed-shell electrons are described by an effective Klappisch potential. The classical trajectory approximation has been used. The method used so far is currently extended from atomic to molecular targets. First results for antiproton collisions with molecular hydrogen are presented.

A 14.7 Di 16:30 Poster C3

Quantum mechanical calculations of multiple-electron loss of fast heavy ions in gas targets — •Gerald Schenk[1], Tom Kirchner[1], and Viatcheslav Shevelko[2] — [1]Institut für Theoretische Physik, TU Clausthal, D-38678 Clausthal-Zellerfeld, Germany — [2]P. N. Lebedev Physical Institute, 119991 Moscow, Russia

Current activities at accelerator facilities, e.g., in the framework of the FAIR project at GSI require precise knowledge of electron stripping cross sections for fast highly-charged ions in gas targets. As a first step toward the goal of providing cross section data for lowly-charged uranium ions from the MeV to the GeV regime we have considered electron loss from sixfold and eightfold argon ions in helium and argon gases at around 10 MeV/amu. Our calculations are based on the independent-electron approximation and the coupled-channels basis generator method (BGM) [1] for orbital propagation. In the case of Ar^{6+} ions we find that a considerable fraction of electron loss is due to ionization from the L-shell. Consequently, Auger processes have to be taken into account to arrive at realistic results for multiple-electron loss. Antiscreening also contributes considerably to the electron loss. It is not unlikely that both processes are also important for the uranium ions of interest at GSI [2].

References: [1] O.J. Kroneisen et al., J. Phys. A 32 (1999) 2141 [2] R.E. Olson et al., J. Phys. B 37 (2004) 4539

A 14.8 Di 16:30 Poster C3

Ein In-Ring Reaktionsmikroskop für den kalten Speicherring CSR des MPI-K — •Kai-Uwe Kühnel, Robert Moshammer, Claus-Dieter Schröter und Joachim Ullrich — Max-Planck-Institut für Kernphysik, Saupfercheckweg1, 69117 Heidelberg

Der neue elektrostatische Speicherring CSR, der bei Temperaturen von 2 K betreiben werden soll, befindet sich derzeit am Max-Planck Institut für Kernphysik im Aufbau. In ihm können geladene Teilchen aller Ladungen und Massen mit hinreichend langen Lebensdauern gespeichert werden [1]. Aufgrund der tiefen Temperaturen wird ein Aufheizen des Strahls durch Schwarzkörperstrahlung vermieden, wodurch Molekül-Ionen in ihrem rovibronischen Grundzustand präpariert werden können und somit für Experimente zur Verfügung stehen. Mit einem In-Ring Reaktionsmikroskop als eines der zentralen Experimente wird es möglich sein, Ionen-Atom Stöße bei Projektil-Energien von 20-300 keV kinematisch vollständig zu untersuchen [2]. Mit dem Spektrometer, das auf maximale Flexibilität ausgelegt ist, können dann neben Target-Ionisation auch Austausch-Reaktionen und Fragmentationen von molekularen Gastargets untersucht werden. Aufgrund des neuartigen Spektrometer-Designs ist der koinzidente Nachweis von emittierten Photonen sowie die Durchführung von Laser-Experimenten an gespeicherten Ionen möglich. Das Konzept des im Aufbau befindlichen Reaktions-Mikroskops und geplante Experimente werden vorgestellt.

[1] D. Zajfmann et al., Journal of Physics. Conference Series
[2] J. Ullrich et al., Rep. Prog. Phys.

A 14.9 Di 16:30 Poster C3

Berechnung von Stößen von Protonen und Alphateilchen mit atomarem Sauerstoff mit Hilfe der Zwei-Zentren-Basis-Generator-Methode — •Tobias Spranger und Tom Kirchner — Institut für Theoretische Physik, TU Clausthal, 38678 Clausthal-Zellerfeld, Deutschland

Es werden Stöße von Protonen und Alphateilchen mit atomarem Sauerstoff betrachtet und totale Wirkungsquerschnitte für Einfach- und Doppelionisation, Doppeleinfang und Transferionisation von Sauerstoff berechnet. Dabei werden die Einzentren- und Zweizentrenvarianten der Basis-Generator-Methode (BGM) miteinander verglichen.

Eine frühere Studie [1] dieses Stoßsystems in einer einzentrigen Basis zeigte, verglichen mit Stößen an Edelgasatomen [2], relativ große Abweichungen zu den Experimenten. Mit der Zwei-Zentren-BGM möchten wir versuchen, die Ursache der Abweichungen zu den Messwerten aufzuklären und zu verringern.

[1] T. Kirchner *et al*, Phys. Rev. A 61, 052710 (2000)
[2] T. Spranger and T. Kirchner, J. Phys. B 37, 4159 (2004)

A 14.10 Di 16:30 Poster C3

Erste Experimente mit dem In-Ring Reaktionsmikroskop im Schwerionen-Speicherring ESR der GSI — •Daniel Fischer[1,2], Robert Moshammer[2], Siegbert Hagmann[3,4], Thomas Ferger[2], Magnus Gudmundsson[1], Kai-Uwe Kühnel[2], Marco Schäfer[2], Markus Schöffler[4], Muafaq Nofal[3], Harald Bräuning[3], Carsten Brandau[3], Chritophor Kozhuharov[3], Thomas Stöhlker[3] und Joachim Ullrich[2] — [1]Departement of Physics, Stockholm University, 10 691 Stockholm, Schweden — [2]Max-Planck-Institut für Kernphysik, Heidelberg — [3]Gesellellschaft für Schwerionenforschung mbH, Darmstadt — [4]Universität Frankfurt

Zur Untersuchung der Ionisation und des Elektroneneinfangs in schnellen Stößen zwischen hochgeladenen Ionen (highly charged ions, HCI) und Atomen, wurde in den Experimentier-Speicherring (ESR) der GSI ein Reaktionsmikroskop eingebaut. Damit ist es möglich die vollständige kinematische Information von Stößen, d.h. die Impulsänderung aller am Stoß beteiligter Teilchen, zu vermessen. In Kombination mit dem Ionenspeichering, mit dem Strahlen von Ionen mit geringer Emittanz und hoher Intensität bereitgestellt werden können, steht ein hervorragendes Mittel zur Verfügung, die Dynamik schneller HCI-Atom-Stöße hochdifferentiell zu untersuchen. Die Ergebnisse erster Messungen im ESR sowie die in naher Zukunft geplanten Experimente nach der Implementierung des Spektrometers in den Test-Speicherring (TSR) des MPI-K in Heidelberg werden vorgestellt.

A 14.11 Di 16:30 Poster C3

Projectile angular-differential cross sections for inelastic processes in ion-atom collisions — Myroslaw Zapukhlyak, •Nils Henkel, and Tom Kirchner — Institut für Theoretische Physik, TU Clausthal, 38678 Clausthal-Zellerfeld, Germany

Angular-differential projectile scattering has been investigated theoretically with the two-center extension of the nonperturbative basis generator method for various one- and two-electron inelastic transition processes in keV ion-atom collisions. The eikonal approximation has been used to extract angular-differential cross sections from impact-parameter-dependent transition amplitudes. Different models for one- and two-electron impact-parameter-dependent transition amplitudes have been applied in order to analyse the role of electron-electron correlation, quantum mechanical heavy-particle-electron couplings and the limits of the independent electron model in the collision systems under consideration. Quantum effects have been observed and identified via comparisons with classically calculated differential cross sections and experimental data.

A 14.12 Di 16:30 Poster C3

Electron emission from insulators irradiated by slow highly charged ions — •Martin C. Simon[1,2], Walter Meissl[1], Daniel Winklehner[1], Rainer Ginzel[2], José R. Crespo López-Urrutia[2], Joachim Ullrich[2], and Friedrich Aumayr[1] — [1]Institut für Allgemeine Physik, Vienna University of Technology, Wiedner Hauptstraße 8-10/134, A-1040 Vienna, Austria — [2]Max-Planck Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany

Electron emission induced by impact of slow highly charged ions (HCI) on metallic surfaces has been studied extensively over the past 15 years. The "classical-over-the-barrier"(COB) model was very successful in modeling the formation of so-called "hollow atoms"in front of the surface and the subsequent emission of electrons. For insulator surfaces the response to slow HCI impact is not as well understood due to the finite hole mobility and differences in image charge potentials. We measured total electron yields from insulating LiF(001) and CaF_2(111) surfaces bombarded by slow (v < 1 a.u.) projectile ions of charge states up to 68+ for various impact angles.

In contrast to metallic surfaces the kinetic electron emission from the insulating surfaces can not be neglected. We present ways to subtract the kinetic emission part and to determine the pure potential electron emission contribution, finding a drastically different behavior for the potential electron emission from insulators as compared to metallic surfaces.

This work has been supported by: Austrian FWF (Proj. No. P17449-N02), European Project RII3 026015, Association EURATOM-ÖAW.

A 14.13 Di 16:30 Poster C3

Niederenergetische Elektronen aus Ion-Atom Stößen in Festkörpertargets — •Natalia Lineva, Siegbert Hagmann, Christophor Kozhuharov, Michael Krämer und Gerhard Kraft — GSI Darmstadt

Um die biologisch wirksame Dosis bei Bestrahlungen mit Ionen zu ermitteln, werden Wirkungsquerschnitte für die Emission und Transport niederenergetischer Elektronen in kondensierter Meterie benötigt, die überwiegend aus experimentellen und theoretischen Untersuchungen mit Gastargets gewonnen werden. Auch die radiale Dosisverteilung wird aus Messungen mit Gewebe-Äquivalenten Gaszählern extrahiert.

Um die Gas/Festkörper-Unterschiede zu studieren, wurden am UNILAC-Beschleuniger der GSI dünne Festkörpertargets (C, Ni, Ag, Au) mit Protonen und Kohlenstoff bestrahlt, und die emittierten Elektronen (E < 1 keV) mit einem elektrostatischen Toroidspektrometer winkeldifferentiell untersucht. Die gemessenen Spektren werden mit einfachen theoretischen Voraussagen und mit Monte Carlo Simulationen verglichen.

Die Targetdicken bei sehr dünnen Folien zeigen starke mikroskopische Schwankungen, die mit monoenergetischen Elektronenstrahlen untersucht wurden. Der Vergleich der resultierenden Elektronenspektren mit Simulationen erlaubt, effektive Dicken abzuleiten.

A 14.14 Di 16:30 Poster C3

Electron Loss to Continuum in Near-relativistic Ion-Atom Collisions — •Siegbert Hagmann[2,3], Muaffaq Nofal[1,2,3], Thomas Stöhlker[2,4], Andrey Surzhykov[1], Stefan Fritzsche[2,4], Christophor Kozhuharov[2], Robert Moshammer[1], Joachim Ullrich[1], Alexander Gumberidze[2], Uwe Spillmann[2], Regina Reuschl[2], Sebastian Hess[2], Sergej Trotsenko[2], Fritz Bosch[2], Dieter Liesen[2], Reinhard Dörner[3], and Hermann Rothard[5] — [1]Max Planck Inst. f. Kernphysik, Heidelberg — [2]GSI, Darmstadt — [3]Inst. f. Kernphysik, Univ. Frankfurt — [4]Physikal. Institut, Univ. Heidelberg — [5]CIRIL, GANIL, Caen, France

In fast ion-atom collisions the projectile electron loss to continuum (ELC) permits to study the dynamics of ionization very close to threshold; it is a test of unparalleled sensitivity for first order theories. We have studied forward electron emission in two collision systems of different projectile Compton profile, U88+ + N2 and Sn47+ + N2 using the forward electron spectrometer at the supersonic jet-target of the ESR storage ring. We report first results for 90AMeV U88+ and 300AMeV Sn47+ measuring coincidences between electrons around ve=vProj and charge-exchanged projectiles having lost one electron; results are compared with theory.

A 14.15 Di 16:30 Poster C3

One- and Two-Electron ECC-Processes in 90 AMeV U88+ + N2 collisions — Muaffaq Nofal[1,2,3], •Siegbert Hagmann[2,3], Thomas Stöhlker[2,4], Doris Jakubassa-Amundsen[5], and Christophor Kozhuharov[2] — [1]Max Planck Inst. f Kernphysik, Heidelberg — [2]GSI, Darmstadt — [3]Inst. f. Kernphysik, Univ. Frankfurt — [4]Physikal. Institut, Univ. Heidelberg — [5]Mathemat. Inst., LMU München

Theories for electron transfer to the continuum have encountered considerable difficulties to take into account the intrinsic many-electron processes in the capture channel. This may partially be attributed to large momentum transfers involved and thus collision systems are mostly not in the realm of first order perturbation theories. For this reason we have studied the non-radiative electron capture to continuum (ECC) in the relativistic domain where one or two active electrons are involved. Using the imaging forward electron spectrometer in the ESR target zone we have studied simultaneously both, 1-and 2-electron ECC, and report first results.

A 14.16 Di 16:30 Poster C3

Theoretical analysis of cascading effects on the nonstatistical enhancement of the $1s2s2p^4P$ state in electron transfer in C^{4+}-He collisions — •Dennis Röhrbein[1], Tom Kirchner[1], Stephan Fritzsche[2,3], Diane Strohschein[4], Jamie Baran[4], and John Tanis[4] — [1]Institut für Theoretische Physik, TU Clausthal, D-38678 Clausthal-Zellerfeld — [2]GSI, D-64291 Darmstadt — [3]Max-Planck-Institut für Kernphysik, D-69029 Heidelberg — [4]Department of Physics, Western Michigan University, Kalamazoo MI 49008, USA

In several experiments nonstatistical enhancements for formation of

the metastable $1s2s2p^4P$ state compared to the similarly configured $1s2s2p^2P_-$ and $1s2s2p^2P_+$ states following single electron transfer to a $1s2s^3S$ state have been observed. The enhancements were attributed to a dynamical Pauli exchange mechanism involving projectile and target electrons having the same spin alignment. Recently, it was suggested that the enhancements might be due to cascading effects following electron transfer to levels with $n \geq 3$.

To test the latter interpretation we have combined dynamical capture calculations on the single-particle level with structure calculations for the relevant excited three-particle states. The E1 transition rates have been calculated for all these states up to n=5, and the dynamical rate equations solved to obtain total cross sections for the final ^4P and ^2P states under consideration. These results are compared with new measurements for 500-1000 keV/amu C^{4+}-He collisions. It is found that cascade feeding due to capture into $n \geq 3$ levels does indeed play a role, but explains only about half of the observed enhancement.

A 14.17 Di 16:30 Poster C3

Der Elektron-Kern-Thomass-Prozess in Proton-Helium-Stössen bei Projektilenergien zwischen 630 keV und 1,2MeV — •Hong-Keun Kim — Institut für Kernphysik, Frankfurt am Main, Deutschland

In H^+-Helium-Stössen wurde der Einelektronentransfer (single capture, SC) bei Projektilenergien von 630 keV, 1 MeV und 1,2 MeV untersucht. Bei hohen Projektilgeschwindigkeiten findet der Elektronentransfer vornehmlich durch den Elektron-Kern-Thomas-Prozess statt. Bei niedrigeren Projektilenergien dominiert der kinematische Einfang gegenüber dem Thomas-Prozess. Im Experiment wurde untersucht ob bei hinreichend guter Auflösung der Thomas-Prozess auch bei vergleichsweise niedrigen Projektilenergien anhand seiner eindeutigen Signatur im Projektilstreuwinkel identifiziert werden kann. Die hier vorgestellten differentiellen Wirkungsquerschnitte wurden mit Hilfe der Rückstossionenimpulsspektroskopie (COLTRIMS) ermittelt.

A 15: Precision spectroscopy I

Zeit: Donnerstag 8:30–10:30 Raum: 3C

Hauptvortrag A 15.1 Do 8:30 3C

Correlations and Quantum Electrodynamics effects in He-like uranium — •M. Trassinelli[1,2,3], A. Kumar[1], H.F. Beyer[1], C. Brandau[1], H. Bräuning[1], S. Geyer[1], A. Gumberidze[1], P. Indelicato[4], P. Jagodzinski[5], Ch. Kozhuharov[1], S. Hess[1], R. Märtin[1], R. Reuschl[1], Th. Stöhlker[1,3], S. Trotsenko[1], and G. Weber[1,3] — [1]Gesellschaft für Schwerionenforschung, Darmstadt, Germany — [2]Institut des Nanosciences de Paris, France — [3]Physikalisches Institut, Heidelberg, Germany — [4]Laboratoire Kastler Brossel, Paris, France — [5]Akademia Swietokrzyska, Kielce, Poland

Electrons bound to a nucleus with a charge as high as Z=92 represent a unique probe of relativistic and Quantum Electrodynamics effects in the domain of strong fields. As compared to a one-electron and many-electron ions, heliumlike ions are the simplest multibody systems where the role electron-electron interaction in extreme conditions can be theoretically treated in a rigorous way. We present the first highly accurate measurement of the intra-shell transition $1s2p\ ^3P_2 \rightarrow 1s2s\ ^3S_1$ of He-like uranium performed via X-ray spectroscopy. The present experiment has been conducted at the gas-jet target of the ESR storage ring in GSI (Darmstadt, Germany) where a Bragg spectrometer, with a bent germanium crystal, was mounted. A high systematic accuracy has been achieved making use of a differential measurement between He- and Li-like ions. With this method, it was possible to measure the $1s2p\ ^3P_2 \rightarrow 1s2s\ ^3S_1$ He-like U transition energy, at 4510 eV, with respect to the $1s^22p\ ^2P_{3/2} \rightarrow 1s^22s\ ^2S_{1/2}$ Li-like U transition energy, at 4460 eV, with an estimated uncertainty of about 0.5 eV.

A 15.2 Do 9:00 3C

Test der Lorentz-Invarianz mit einem ^{3}He-^{129}Xe-Komagnetometer — •Christian Ludwig[1], Stefan Baessler[3], Martin Burghoff[2], Claudia Gemmel[1], Werner Heil[1], Wolfgang Kilian[2], Wolfgang Müller[2], Allard Schnabel[2], Frank Seifert[2], Yuri Sobolev[1] und Lutz Thrams[2] — [1]Universität Mainz — [2]PTB Berlin — [3]University of Virginia

Ziel des Experimentes ist es, eine Variation der Präzessionsfrequenz der ^{3}He-/^{129}Xe -Spins mit der Periode eines Sternentages zu messen, was eine Verletzung der Lorentz-Invarianz bedeuten würde.

In einem schwachen und sehr homogenen Magnetfeld von 400 nT, das in einem magnetisch abgeschirmten Raum an der PTB Berlin aufgebaut ist, wird das Gemisch aus polarisierten Gasen zur Spinpräzession angeregt. Die Präzessionsfrequenz wird mit einem SQUID-System über einen Zeitraum von mehreren Stunden aufgezeichnet, wobei Signal-zu-Rausch Verhältnisse größer 1000:1 erzielt werden. Die gemessenen transversalen T_2-Spinrelaxationszeiten betragen für ^{129}Xe bis zu 4.5h und für ^{3}He bis zu 60h. Mit der Differenz der Präzessionsfrequenzen beider Gase, die sich im gleichen Volumen befinden, eliminiert man den Zeeman-Term und ist somit nicht mehr auf Magnetfeldänderungen empfindlich. Dadurch lässt sich eine sehr hohe Empfindlichkeit auf mögliche Lorentz-Invarianz verletzende Effekte erreichen.

In meinem Vortrag sollen die bisherigen Messungen und erste Ergebnisse vorgestellt werden.

A 15.3 Do 9:15 3C

Test der relativistischen Zeitdilatation mit schnellen optischen Uhren — •Sascha Reinhardt[1,3], Guido Saathoff[1,3], Henrik Buhr[1], Lars A. Carlson[1], Andreas Wolf[1], Dirk Schwalm[1], Sergei Karpuk[2], Christian Novotny[2], Gerhard Huber[2], Marcus Zimmermann[3], Ronald Holzwarth[3], Thomas Udem[3], Theodor W. Hänsch[3] und Gerald Gwinner[4] — [1]MPI für Kernphysik, 69029 Heidelberg, Germany — [2]Institut für Physik, Universität Mainz, 55099 Mainz, Germany — [3]MPI für Quantenoptik, 85478 Garching, Germany — [4]Dept. of Physics & Astronomy, University of Manitoba, Winnipeg R3T 2N2, Canada

In einem Experiment an schnellen optischen Uhren, die durch Lithium-Ionen realisiert wurden, haben wir den bisher genauesten Test der von der Speziellen Relativitätstheorie vorhergesagten Zeitdilatation durchgeführt.

Die Grundlage des Experiments ist der Testspeicherring am MPI für Kernphysik, der es ermöglicht Lithium Ionen bei 3% oder 6.4% der Lichtgeschwindigkeit zu speichern. An einem geeigneten Übergang dieser gespeicherten Ionen werden mithilfe von Laserspektroskopie für beide Geschwindigkeiten die Übergangsfrequenz durch zwei gegenläufige Laser bestimmt und miteinander verglichen.

Die Ergebnisse sind konsistent mit der Relativitätstheorie und liefern eine neue obere Grenze für eine mögliche Abweichung, die im Rahmen der Robertson-Mansouri-Sexl Testtheorie einen Wert von $|\hat{\alpha}| < 8.4 \times 10^{-8}$ ergibt [1].

[1] S. Reinhardt et al., Nature Physics,doi:10.1038/nphys778

A 15.4 Do 9:30 3C

Erste Doppler-freie Spektroskopie an metastabilen Lithium-Ionen bei 34%c im Experimentier-Speicherring der GSI — •Christian Novotny[1], G. Huber[1], S. Karpuk[1], W. Nörtershäuser[1], D. Bing[2], S. Reinhardt[2], D. Schwalm[2], A. Wolf[2], G. Gwinner[3], G. Ewald[4], C. Geppert[4], H.-J. Kluge[4], T. Kühl[4], T. Stöhlker[4], B. Bernhardt[5], T. W. Hänsch[5], R. Holzwarth[5], G. Saathoff[5] und T. Udem[5] — [1]Johannes Gutenberg Universität Mainz — [2]MPI für Kernphysik, Heidelberg — [3]University of Manitoba, Winnipeg, Canada — [4]Gesellschaft für Schwerionenforschung, Darmstadt — [5]MPI für Quantenoptik, Garching

Am Experimentier-Speicherring (ESR) der GSI konnte die erste Doppler-freie Spektroskopie an metastabilen $^7Li^+$-Ionen bei einer Teilchengeschwindigkeit von 34%c realisiert werden. Hierbei wurden dem Ionenstrahl kollinear zwei Laserstrahlen überlagert, die entweder parallel oder antiparallel zueinander ausgerichtet waren. Die beobachtete Resonanz hat eine Breite von etwa 60 MHz und ist damit 8-9 mal schmaler als das Doppler-verbreiterte Signal. Diese Messungen sind die Grundlage für eine präzise Bestimmung des Zeitdilatationsfaktors der speziellen Relativitätstheorie (SRT) und der erste Schritt zur Verbesserung des Vorgängerexperiments vom MPI für Kernphysik. Dort wurde bei Experimenten mit Ionengeschwindigkeiten von 3%c und 6.4%c eine Obergrenze von hypothetischen Abweichungen zur SRT von 8.4 x 10^{-8} ermittelt [1]. Die Experimente am ESR haben das Potenzial diese Obergrenze um mehr als eine Größenordnung zu verbessern. [1] S. Reinhardt et.al. Nat.Phys. (2007) *doi:10.1038/nphys778*

A 15.5 Do 9:45 3C

Towards a g-factor determination of the bound electron in highly-charged calcium ions — •Birgit Schabinger[1], Klaus Blaum[1,2], Wolfgang Quint[2], Sven Sturm[1], Anke Wagner[1], and Günter Werth[1] — [1]Department of Physics, Johannes Gutenberg-University, 55099 Mainz, Germany — [2]GSI Darmstadt, 64291 Darmstadt, Germany

Bound-state quantum electrodynamical (BS-QED) calculations can be tested by high-precision measurements of the magnetic moment of the electron bound in highly-charged ions. In the past, measurements were performed on hydrogen-like carbon and oxygen [1]. The influence of the BS-QED contribution to the g-factor increases with the nuclear charge. In the current experiment [2] we plan to measure the g-factor of calcium $^{40}Ca^{17+}$ and $^{40}Ca^{19+}$ ions. The ions are created in-trap by a mini electron-beam ion source [3]. The g-factor measurement of a single calcium ion will be performed in a double Penning-trap setup employing the "continuous Stern-Gerlach-effect". The aim is to reach a relative uncertainty in the order of 10^{-9}. In the future, we plan to extend our g-factor measurements up to uranium $^{238}U^{91+}$ at the HITRAP facility at GSI Darmstadt. The charge-breeding process and results of in-trap ion creation and detection will be presented.

[1] G. Werth *et al.*, Int. J. Mass Spec. **251**, 152 (2006)
[2] M. Vogel *et al.*, Nucl. Inst. Meth. B **235**, 7 (2005)
[3] B. Schabinger *et al.*, J. Phys. Conf. Ser. **58**, 121 (2007)

A 15.6 Do 10:00 3C

Entwicklungen zur Bestimmung des g-Faktors des Protons — •Crícia Rodegheri[1], Klaus Blaum[1,2], Holger Kracke[1], Susanne Kreim[1], Wolfgang Quint[2], Stefan Stahl[3], Stefan Ulmer[1,4], José Verdú[5] und Jochen Walz[1] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz — [2]GSI Darmstadt, 64291 Darmstadt — [3]Stahl Electronics, 67582 Mettenheim — [4]Ruprecht-Karls-Universität, 69047 Heidelberg — [5]Atominstitut der Österreichischen Universität, Stadionallee 2, 1020 Wien, Österreich

Ein Überblick zur Messung des magnetischen Momentes eines einzelnen, isolierten Protons in einer zylindrischen Doppel-Penningfalle, bestehend aus einer Analysefalle und einer Präzisionsfalle, wird gegeben. Die verwendete Methode soll die erste direkte Messung des g-Faktors an einem einzelnen Proton ermöglichen, wobei eine Messgenauigkeit von 10^{-9} angestrebt wird. Der g-Faktor lässt sich aus zwei experimentell zugänglichen Eigenfrequenzen des Protons gemäß $g = 2\frac{\nu_L}{\nu_c}$ berechnen, wobei ν_c die freie Zyklotronfrequenz bezeichnet, welche über die Eigenfrequenzen in der Präzisionsfalle bestimmt wird. Die Larmorfrequenz ν_L wird mit Hilfe des kontinuierlichen Stern-Gerlach-Effekts in der Analysefalle ermittelt. Der zerstörungsfreie Nachweis der Eigenfrequenzen des Teilchens basiert auf der Messung der durch das Teilchen in den Fallenelektroden induzierten Spiegelströme, die über supraleitende HF-Resonatoren nachgewiesen werden. Das Experiment wird in einer kryogenen Umgebung durchgeführt, woraus eine Erhöhung des Signal-zu-Rausch-Verhältnisses resultiert. Außerdem liefert das vorhandene Kryovakuum extrem lange Speicherdauern.

A 15.7 Do 10:15 3C

Erste Messungen mit der Mainzer g-Faktor Apparatur — •Susanne Kreim[1], Klaus Blaum[1,2], Holger Kracke[1], Wolfgang Quint[2], Crícia Rodegheri[1], Stefan Ulmer[1,3] und Jochen Walz[1] — [1]Institut für Physik, Universität Mainz, 55099 — [2]GSI, 64291 Darmstadt, — [3]Ruprecht-Karls-Universität, 69047 Heidelberg

Das Experiment zur Bestimmung des g-Faktors eines einzelnen Protons wird in einem zylindrischen Penningfallenturm durchgeführt (s. Beitrag von C. Rodegheri). Der Fallenturm ist in einer in sich geschlossenen kryogenen UHV-Kammer montiert, wobei durch den Kryopumpeffekt Drücke $< 10^{-16}$ mbar und damit lange Speicherzeiten erzielt werden. Aus diesem Grund muss das zu untersuchenden Proton innerhalb des Fallenturms erzeugt werden, was über den Beschuss eines Polyethylentargets mit Elektronen im Inneren der Fallenkammer erreicht wird. Eine Elektronenkanone basierend auf Nanodrähten wurde entwickelt, die in hohem Magnetfeld und 4K Umgebung stabil und zuverlässig arbeitet. Die ersten Testmessungen in der Apparatur mit Elektronenkanone und vollständiger Verkabelung der Fallenelektroden werden vorgestellt. Dabei wurden die Funktionstüchtigkeit der Fallenelektroden, der Leitungen sowie das thermische Verhalten von Filterplatinen und Elektronikkomponenten untersucht. Zur Zeit werden die Nachweissysteme zur Bestimmung der Bewegungsmoden in der Penningfalle implementiert, um in Kürze Teilchenwolken bzw. ein einzelnes Proton zerstörungsfrei nachzuweisen.

A 16: Atomic Clusters

Zeit: Donnerstag 8:30–10:30 Raum: 3D

A 16.1 Do 8:30 3D

PES study of the photodetachement of water clusters — •Lei Ma, Kiran Majer, Raphael Kuhnen, Fabien Chirot, and Bernd von Issendorff — FMF, Freiburg, Deutschland

The photodetachement of size-selected water cluster anions have been investigated by photoelectron spectroscopy (PES). New features have been observed in the PES spectra for small water clusters ($(H_20_n)^-$, n = 15-25)and heavy-water clusters. In heavy-water clusters, and in some cold (10 K) water clusters, the spectra are consistent with the existence of different isomers. The difference of the electron binding energies in these isomers is in agreement with previous work[1], and could give useful information on the location of the excess electron inside or outside the cluster. This is an important issue for using water clusters as nano-scale analogue of the bulk hydrated electron.

Furthermore, the PES spectra of water clusters show evidence of resonant two-photon photodetachement for cluster as small as $(H_20_{20})^-$. This two photon process have been studied using femtosecond PES.

[1] Verlet *et al.*, Science **307**, 93 (2005)

A 16.2 Do 8:45 3D

Optical properties and electronic structure of ideal nanodiamonds — Lasse Landt[1], Kathrin Klünder[1], Jeremy Dahl[2], Bob Carlson[2], Thomas Möller[1], and •Christoph Bostedt[1] — [1]IOAP - Technische Universität Berlin — [2]MolecularDiamonds Technologies

Diamondoids can be considered the smallest possible cage-like subunits that can be excised from diamond lattice closing the gap between large hydrocarbon molecules and nanodiamonds. The optical and electronic properties of perfectly size- and structure-selected, neutral, and surface-passivated diamondoids ranging in size from 0.5 to 1 nm have been determined by means of PES, XAS, and optical absorption measurements. All data were taken from high purity samples in the gas phase revealing optical gap and band edges with near theoretical purity. We find that the optical properties of the perfectly size- and shape-selected nanocrystals exhibit strong shape dependence unlike band edges or ionization potentials which have also been determined. The observed isomeric dependencies of the optical gap will be discussed and first experimental data on the influence of targeted surface modification (e.g. thiols, alcohols) will be presented.

A 16.3 Do 9:00 3D

Heliumdimere untersucht in langsamen Stössen mit Ar^{2+} — •Jasmin Titze, Markus Schöffler, Hong-Keun Kim, Robert Grisenti, Lothar Schmidt, Nadine Neumann, Ottmar Jagutzki, Horst Schmidt-Böcking und Reinard Dörner — Johann Wolfgang Goethe-Universität, Frankfurt, Germany

Heliumdimere stellen das am weitesten gebundene atomare System dar; die Bindungslänge kann die von C60 übersteigen. In Stössen mit Ar^2+ bei Projektilenergien von 25 keV/u wurde die Zerfallsdynamik nach Elektroneneinfang (ein und zweifach) mittels der COLTRIMS-Technik (COLd Target Recoil Ion Momentum Spectroscopy) untersucht.

A 16.4 Do 9:15 3D

Energy absorption of composite clusters in intense laser fields — •Alexey Mikaberidze, Ulf Saalmann, and Jan-Michael Rost — Max Planck Institut für Physik komplexer Systeme, Dresden, Deutschland

Energy absorption of xenon clusters embedded in helium droplets from intense femtosecond laser pulses is studied theoretically. For sufficiently long pulses we find earlier and more efficient resonant energy absorption for the embedded xenon cluster than for the pure one in agreement with experiments [1]. This effect is due to a plasma resonance in the

helium droplet initiated by the charged xenon core [2]. For ultrashort double pulses with variable delay (pump-probe technique) both plasma resonances, due to the helium droplet and the xenon cluster itself, are identified and the conditions are given [2] which should allow for an experimental observation of both resonances.

[1] T. Döppner *et al.*, Eur. Phys. J. D, **24**, 157 (2003).
[2] A. Mikaberidze, U. Saalmann, J. M. Rost, to be published (2007)

A 16.5 Do 9:30 3D

Higly charged ions from laser cluster interactions — •Thomas Fennel[1,2], Lora Ramunno[2], and Thomas Brabec[2] — [1]Institute of Physics, University of Rostock — [2]Center for Photonics, Ottawa

Today it is widely accepted that resonant plasmon excitations and efficient heating through inverse bremsstrahlung are the dominant mechanisms for the highly efficient absorption of intense IR femtosecond laser pulses by atomic cluster. From experiments it is known that independent of the type of material, intermediate and heavy atom clusters emit ions with high charge states of up q=20-30 already at moderate laser intensities between $10^{14} - 10^{15}$W/cm^2. This has been demonstrated e.g. for Xe_N, Pt_N, and Pb_N. The mechanisms underlying the generation of the measured high ionic charge states, however, is still under discussion. Our molecular dynamics analysis of Xe clusters identifies two physical mechanisms that contribute to this yet unexplained observation of extremely high ionic charge states at moderate laser intensity [1]. First, the local cluster electric field supports electron impact ionization and increases the highest ion charge state by up to 40%. Second, the ion charge distribution of the nanoplasma is only weakly affected by electron-ion recombination, as recombination is frustrated by the background electric fields typically used in ion detectors. This increases the highest charge state by up to 90%, as compared to the usually assumed recombination of all electrons trapped in the cluster potential. Both effects together augment the highest charge state by up to a factor of 2 and beyond, in reasonable agreement with experiments.

[1] T. Fennel *et* al., accepted for Phys. Rev. Lett., 2007

A 16.6 Do 9:45 3D

Elektron-Elektron-Stöße in Metall-Clustern bei der Wechselwirkung mit intensiven Laserpulsen — •Jörg Köhn, Thomas Fennel, Ronald Redmer und Karl-Heinz Meiwes-Broer — Institut für Physik, Universitätsplatz 1, Universität Rostock, 18051 Rostock

Eine leistungsfähige Methode zur zeitabhängigen Beschreibung von Metall-Clustern in intensiven Laserfeldern ist die Thomas-Fermi-Vlasov-Molekulardynamik. Die langreichweitige Coulombwechselwirkung der Elektronen wird dabei mit einem mittleren Feld beschrieben. Die Erweiterung des Modells zur Einbeziehung von Elektron-Elektron-Stößen kann mit einem Vlasov-Ühling-Uhlenbeck (VUU)-Schema erfolgen. Bisher wurden die dazu benötigten Streuquerschnitte mit Thomas-Fermi-Abschirmlängen für den Grundzustand des Clusters bestimmt. Nach der Wechselwirkung mit intensiven fs-Laserpulsen formt sich jedoch ein heißes, verdünntes Nanoplasma, in dem Stoßprozesse mit den Querschnitten aus dem Grundzustand nur unzureichend beschrieben werden können. Daher berechnen wir die Streuquerschnitte als Funktion der lokalen Temperatur und Dichte des Nanoplasmas. Die Ergebnisse der VUU-Simulationen zeigen eine verstärkte Energieabsorption bei nichtresonanter Laseranregung. Die Auswirkung auf Pump-Probe-Szenarien wird diskutiert.

A 16.7 Do 10:00 3D

Optimization of the ionization dynamics of clusters in intense laser fields — •Nguyen Xuan Truong, Tilo Döppner, Sebastian Göde, Andreas Przystawik, Josef Tiggesbäumker, and Karl Heinz Meiwes-Broer — Universität Rostock, Fachbereich Physik, Universitätsplatz 3, 18051 Rostock

Xenon clusters embedded in helium droplets are exposed to intense laser fields. Recent work, ranging from the variation of laser pulse duration over dual pulse excitation to self-learning pulse shaping experiments, has confirmed the strong dependence of the highly charged atomic ions on the temporal pulse shape [1-3]. Expecially, it has been shown in both experiments and simulations that the pulse parameters for a certain charge state are different[1]. In this experiment we optimize the generation of a given atomic charge state using pulse modulator (Dazzler) and a Genetic Algorithm. First results are discussed and corroborated by simulations.

[1] Döppner *et al.*, Phys. Rev. Lett. **94**, 013401 (2005).
[2] Moore *et al.*, Appl. Phys. B **80**, 101 (2005).
[3] Martchenko *et al.*, Phys. Rev. A **72**, 053202 (2005).

A 16.8 Do 10:15 3D

Semiclassical approach to the dynamics of Gaussian wave packets in a system with a mixed phase space — •Christoph-Marian Goletz[1], Frank Grossmann[1], and Steven Tomsovic[2] — [1]TU Dresden, Germany — [2]WSU, Pullman, USA

The 2D coupled quartic oscillator is a convenient system for the analysis of mixed dynamics [1]. Using the semiclassical method according to Herman and Kluk [2] we examine the dynamics of a Gaussian wave packet originating in different regions of the phase space. We show that this propagation method is applicable to a wave packet starting in the regular region, at the border of a chaotic and regular region or, to some degree, in the chaotic region.

[1] O. Bohigas, S. Tomsovic and D. Ullmo, Phys. Rep., **223**, p. 43, 1993
[2] M. F. Herman and E. Kluk, Chem. Phys., **91**, p. 27, 1984

A 17: Collision processes and energy transfer I (jointly with MO)

Zeit: Donnerstag 8:30–10:30 Raum: 3F

Hauptvortrag A 17.1 Do 8:30 3F

Reactions of negative ions at low energy — Jochen Mikosch, Sebastian Trippel, Rico Otto, Christoph Eichhorn, Petr Hlavenka, Matthias Weidemüller, and •Roland Wester — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Interactions of negative ions with small organic molecules represent model systems for the investigation of reaction dynamics in few-body systems. Their corrugated potential energy landscape, originating in long-range attractive and short-range repulsive forces, requires the coupling of different degrees of freedom for reactions to occur. We have adopted two complementary approaches to study anion-molecule reaction dynamics. Using velocity map imaging in combination with crossed beams at low energy we study the differential cross section of negative ion reactions. For nucleophilic substitution reactions we have observed several distinct reaction mechanisms when varying the collision energy [1]. Reaction rate measurements in a 22pole ion trap have revealed unexpected temperature-dependences at low temperatures. These results are relevant for the understanding of the negative ion abundances in interstellar molecular clouds.

[1] J. Mikosch et al., Science (in press)

A 17.2 Do 9:00 3F

Manipulation von Protonentransferreaktionen mittels Zustandsselektion — •Franziska Unger, Lisa Paetow und Karl-Michael Weitzel — Fachbereich Chemie, Universität Marburg

Ionen-Molekül-Reaktionen (IMR) sind von großer Bedeutung für zahlreiche natürliche und künstliche Prozesse, insbesondere in der Plasmachemie. Ein wichtiger Vertreter der IMR ist der Protonentransfer (PT), auf dem auch eine der empfindlichsten Methoden der Spurenanalytik, die Protonentransfer-Massenspektrometrie, basiert. Diese ermöglicht Nachweisgrenzen im ppt-Bereich. Eine interessante, bisher nicht vollständig verstandene Frage ist die nach dem Einfluss der Rotation auf Reaktionen zwischen Ionen und Molekülen, speziell im Vergleich exothermer und endothermer Reaktionssysteme. Hier beschreiben wir erstmals eine systematische Untersuchung der Wirkungsquerschnitte für den PT von HBr^+ auf CO_2 (sowie CO) mit Kontrolle des Spin-Bahn-Zustandes und der Molekülrotation des HBr^+-Ions. Wir zeigen, dass der Wirkungsquerschnitt für ein exothermes Reaktionssystem mit der Stoßenergie abnimmt, für ein endothermes Reaktionssystem nimmt er mit der Stoßenergie im Wesentlichen zu. Für beide Systeme hingegen wird der Querschnitt für rotationskalte Ionen maximal. Mögliche Implikationen für technische Prozesse der Plasmachemie werden diskutiert.

A 17.3 Do 9:15 3F

Photodissociation in a strong laser field — •Sebastian Trippel, Christoph Eichhorn, Jochen Mikosch, Rico Otto, Matthias Weidemüller, and Roland Wester — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Strong light fields are known to provide adiabatic alignment of molecules in free space [1]. Furthermore, such light fields can be used to control dissociation dynamics of molecules [2]. Here we present results on the photodissociation of CH_3I molecules in a strong infrared laser field of up to $10^{12}\,W/cm^2$. Using velocity map slice imaging we measure the three-dimensional velocity distribution of the iodine photofragment. The images reveal significant changes of the dissociation dynamics with increasing laser intensity. In particular, we find that the light field couples the two spin-orbit states of iodine during the dissociation. In the future, this work will be extended to study bimolecular collisions in the laser field.

[1] H. Stapelfeldt and T. Seideman, Rev. Mod. Phys. **75**, 543 (2003)
[2] I. Thanopulos and M. Shapiro, Phys. Rev. A **74**, 031401 (2006)

A 17.4 Do 9:30 3F

Interatomic decay of inner-valence-excited states in clusters — •Kirill Gokhberg, Vitali Averbukh, and Lorenz S. Cederbaum — Theoretische Chemie, Physikalisch-Chemisches Institut, Universitaet Heidelberg, INF 229, 69120 Heidelberg, BW

In an isolated atom, excitation of an inner valence electron above the outer valence subshell leads to creation of an autoionizing state decaying by the resonant Auger mechanism. Recently, it has been demonstrated experimentally that in a cluster, the inner-valence-excited states can decay also by an interatomic mechanism which has been called resonant interatomic Coulombic decay (RICD). Here we show that RICD is indeed the leading, but not the only possible interatomic decay mode of the inner-valence excitations in clusters [1]. Using Ne ($2s \rightarrow 3p$) excitation in MgNe cluster as an example, we explore the possible decay mechanisms and draw conclusions on their relative importance and on the nature of the corresponding decay products.

1. K. Gokhberg, V. Averbukh, and L.S. Cederbaum, J. Chem. Phys. **124**, 144315 (2006)

A 17.5 Do 9:45 3F

Druck- und temperaturabhängige Flugzeitmessungen gepulster Argon-Überschallstrahlen: Datenauswertung und Schlußfolgerungen bezüglich Kühlung und Kondensation — •Tim Krause, Klaus Rademann und Wolfgang Christen — Institut für Chemie, Humboldt-Universität zu Berlin, Brook-Taylor-Strasse 2, 12489 Berlin

Vorgänge wie die Abkühlung und Kondensation in einer Überschallexpansion sind bis heute nicht vollständig verstanden. So wurde kürzlich gezeigt [1], dass die Expansion oberhalb des kritischen Punktes zu einer überraschend schmalen Geschwindigkeitsverteilung führen kann. Bei der Charakterisierung stellen gepulste Molekularstrahlen eine zusätzliche Schwierigkeit dar. Daher wurde mittels Variation des Stagnationsdrucks p_0 (10^2 kPa $< p_0 <$ 10^4 kPa) und der Stagnationstemperatur T_0 (310 K $< T_0 <$ 410 K) systematisch deren Wirkung auf die Flugzeitverteilung eines Argonstrahls untersucht. Durch eine präzise Regelung der Zustandsgrößen p_0 und T_0 ist eine hohe Genauigkeit und Reproduzierbarkeit möglich [2]. Die Bestimmung der charakteristischen Parameter, mittlere Strömungsgeschwindigkeit v_0 und Breite der Geschwindigkeitsverteilung $\Delta v_{\parallel}$, des gepulsten Überschallstrahls wird vorgestellt.

[1] W. Christen, K. Rademann, U. Even, *J. Chem. Phys.* **125**, 174307 (2006)
[2] W. Christen, T. Krause, K. Rademann, *Rev. Sci. Instrum.* **78**, 073106 (2007)

A 17.6 Do 10:00 3F

Dissociative recombination of the lowest rotational states of H_3^+ — •Annemieke Petrignani[1], Holger Kreckel[2], Max H. Berg[1], Simon Altevogt[1], Dennis Bing[1], Henrik Buhr[3], Michael Froese[1], Jens Hoffmann[1], Brandon Jordon-Thaden[1], Claude Krantz[1], Mario B. Mendes[1], Oldrich Novotný[1], Steffen Novotny[1], Dmitry A. Orlov[1], Sascha Reinhardt[1], Tobias M. Sorg[1], Julia Stützel[1], and Andreas Wolf[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Columbia University, 550 West 120th Street, New York, NY 10027, USA — [3]Department of Particle Physics, Weizmann Institute of Science, 76100 Rehovot, Israel

The dissociative recombination (DR) of the lowest rotational states of H_3^+ have been investigated at the storage ring TSR using a cryogenic 22-pole radiofrequency ion trap as injector. The H_3^+ was cooled through buffer gas at ∼15K to the two lowest rotational levels, (J,G)=(1,0) and (1,1), of the ortho and para proton-spin symmetries. New high-statistics scans of the DR with a photocathode electron source reveal resonances at electron energies down to the 1-10 meV range with ∼0.5-1.5 meV collision-energy resolution. The effect of rotational heating is demonstrated by comparing to the rate of a hot H_3^+ beam from a Penning source. Additionally, the reaction dynamics of the 2-body and 3-body break-up for low collision energies were investigated. Comparisons were made using normal- and pure para-H_2 in the cold injection source.

A 17.7 Do 10:15 3F

Winkelabhängigkeit in molekularen Aufbruchreaktionen mit langsamen Elektronen — •S. Novotny[1], H. Rubinstein[2], H. Buhr[1], O. Novotny[1], J. Hoffmann[1], M.B. Mendes[1], D.A. Orlov[1], M.H. Berg[1], S. Jaroshevich[3], B. Jordan-Thaden[1], C. Krantz[1], M. Lange[1], M. Lestinsky[1], A. Petrignani[1], D. Shafir[2], D. Zajfman[2], D. Schwalm[1,2] und A. Wolf[1] — [1]Max-Planck Institut für Kernphysik, Heidelberg — [2]Weizmann Institute of Science, Rehovot 76100, Israel — [3]Institute of Semiconductor Physics, 630090 Novosibirsk, Russia

Die Fragmentationskinematik positiver Molekülionen beim Einfang langsamer Elektronen, der sogenannten Dissoziativen Rekombination (DR), wurde am Schwerionenspeicherring TSR, Heidelberg, mit Hilfe eines hochauflösenden Fragmentabbildungsdetektors untersucht. Die gleichzeitige Überlagerung zweier unabhängiger, kalter Elektronenstrahlen ermöglichte dabei, sowohl die freiwerdende kinetische Energie als auch die Winkelverteilung der neutralen Fragmente des HD^+ Moleküls auf einem feinmaschigen Gitter zwischen ca. 10 und 80 meV Kollisionsenergie zu bestimmen. Wegen der thermischen Rotations-Anregung des HD^+ bei Zimmertemperatur und des resonanten Charakters der DR werden Energiebereiche mit stark variierenden Beiträgen niedrig- und hochrotierender Moleküle zum DR Signal beobachtet. Auch die Anisotropie der DR-Fragmente variiert vergleichbar auf der meV-Skala. Die Stärke der Anisotropie und deren Variation deuten darauf hin, dass die Elektronen- und Kernbewegung des Molekülions eng miteinander gekoppelt sind.

A 18: Ultracold atoms II (jointly with Q)

Zeit: Donnerstag 8:30–10:00 Raum: 2F

A 18.1 Do 8:30 2F

Towards laser cooling of negative ions — •Raoul Heyne, Jan Meier, Ulrich Warring, and Alban Kellerbauer — Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg

Currently available ion cooling techniques do not allow the cooling of negatively charged particles confined in an ion trap to a temperature lower than that of the (cryogenic) environment. The proposed laser cooling of negative osmium ions [1] holds the prospect of achieving temperatures well below 1 mK. Cooling antiprotons with this technique might open the door to forming antihydrogen at ultra-cold temperatures, thus allowing precision antimatter studies. We will outline the unique techniques and challenges involved in this cooling scheme and report intermediate results on Os^- production, manipulation, and spectroscopy.

[1] A. Kellerbauer and J. Walz, "A novel cooling scheme for antiprotons," New J. Phys. **8** (2006) 45.

A 18.2 Do 8:45 2F

Slicing a Bose-Einstein Condensate: Direct observation of number squeezing — •Christian Gross, Jerome Esteve, Andreas Weller, Stefano Giovanazzi, and Markus K. Oberthaler — Kirchhoff Institut für Physik, Universität Heidelberg

Todays interferometers are very often limited by the standard quantum limit. Pushing the performance beyond this limit demands the use of number squeezed states.

We report on the direct observation of number squeezed states in Bose-Einstein Condensates (BEC). These are produced by ramping up a one dimensional optical lattice adiabatically, slicing an initially almost pure condensate of ^{87}Rb atoms into seven pieces.

Our system can be described as an array of Josephson junctions. The effective interaction between the atoms increases with barrier height and their motion is more and more restricted to single wells since the tunneling coupling across the junctions decreases. In this regime the ground state of the Josephson junction array is characterized by a loss of phase coherence and sub shot noise atom number fluctuations across the junctions.

A 18.3 Do 9:00 2F

Observation of dark soliton oscillations in a harmonic trap — •Andreas Weller, Christian Gross, Jens Philipp Ronzheimer, Jerome Esteve, and Markus K. Oberthaler — Kirchhoff Institut für Physik, Universität Heidelberg

We experimentally create dark solitons in a Bose Einstein Condensate confined in a harmonic optical dipole trap by releasing atoms from a double well potential into a harmonic potential. The two clouds collide and form a dark soliton train. We observe the consequent dynamics (oscillations) with a novel imaging system. Furthermore we confirm that the oscillation frequency deviates from the harmonic trapping frequency and is close to the prediction of the one dimensional Gross Pitaevskii Equation (GPE): $\omega_{ds} = \omega_{trap}/\sqrt{2}$. The deviations are consistent with the results obtained by integration of the three dimensional GPE.

We will further discuss the status of the experiment creating intrinsically localized modes and bright solitons by starting with a single occupied well in an optical lattice.

A 18.4 Do 9:15 2F

Quantum State Engineering via Dissipation — •H.P. Büchler[1], S. Diehl[2], A. Kantian[2], B. Kraus[3], A. Micheli[2], and P. Zoller[2,3] — [1]Institut für Theoretische Physik, Universität Stuttgart — [2]Institut für Quantenoptik und Quanteninformation, Universität Innsbruck — [3]Insitut für Theoretische Physik, Universität Innsbruck

An open quantum system, whose time evolution is governed by a master equation, can be driven in steady state into a given pure quantum state by an appropriate design of the system-reservoir coupling. This points out a route towards preparing many body states and non-equilibrium quantum phases by quantum reservoir engineering. Here we discuss in detail the example of a driven dissipative Bose Einstein Condensate (BEC), where atoms in an optical lattice are coupled to a bath of Bogoliubov excitations via the atomic current representing local dissipation. In the absence of interactions the lattice gas is driven into a pure state with long range order. Weak interactions lead to a weakly mixed state, which in 3D can be understood as a depletion of the condensate, and in 1D and 2D exhibits properties reminiscent of a Luttinger liquid or a Kosterlitz-Thouless critical phase at finite temperature, with the role of the "finite temperature" played by the interactions.

A 18.5 Do 9:30 2F

Light propagation in ultracold atomic gases confined by optical lattices — •Stefan Rist and Giovanna Morigi — Departament de Fisica, Universitat Autonoma de Barcelona, 08193 Bellaterra, Spain

We develop a theory which describes photon propagation in a medium constituted by ultracold atoms confined by an optical lattice. We discuss in particular the input-output relations taking into account the finite size of the optical lattice and the atoms quantum motion and statistics. This work extends previous studies [1,2] by considering the atomic vibrations at the lattice sites, the finite tunneling matrix elements, and saturation effects of the atomic transitions. The coherence properties of the transmitted light are discussed as a function of the quantum state of the gas.

[1] Deutsch et al. Phys. Rev. A 52, 1394 (1995).
[2] Chong et al. Phys. Rev. B 75, 235124 (2007).

A 18.6 Do 9:45 2F

Superfluid properties of a Bose-Einstein condensate in an optical lattice confined in a cavity — •Aranya bhuti Bhattacherjee — Max Planck-Institute for Physics of Complex System, Noethnitzer Str.38, 01187 Dresden, Germany

In this work, we study the effect of a one dimensional optical lattice in a cavity field with quantum properties on the superfluid dynamics of a Bose-Einstein condensate(BEC). In the cavity the influence of atomic backaction and the external driving pump become important and modify the optical potential. Due to the coupling between the condensate wavefunction and the cavity modes, the cavity light field develops a band structure. This study reveals that the pump and the cavity now emerges as a new handle to control the coherence properties of the BEC, which offer the potential for improved interferometric technique, quantum information processing and efficient control of nonlinear excitations such as solitons. A wealth of new phenomena can be expected in the many-body physics of quantum gases with pump-cavity mediated interaction. Expressions for the tunneling parameter, the Bloch energy, the Bogoliubov spectrum and the effective mass in a quantum optical lattice are new results, derived here for the first time.

A 19: Ultracold Rydberg gases (jointly with Q)

Zeit: Donnerstag 8:30–10:00 Raum: 2G

A 19.1 Do 8:30 2G

Rydberg excitation of a Bose-Einstein condensate — •Ulrich Raitzsch, Rolf Heidemann, Vera Bendkowsky, Björn Butscher, Robert Löw, and Tilman Pfau — 5. Physikalisches Institut, Pfaffenwaldring 57, 70569 Stuttgart, Germany

We present our latest results on Rydberg excitation of a Bose-Einstein condensate [1]. Crossing the critical temperature T_c, a signature of the phase transition to Bose condensation is observed in the fraction of excited Rydberg atoms. The main features in the experimental data were reproduced by a simulation using a superatom model. A superatom is formed by N ground state atoms in a sphere with the blockade radius $r_b \propto \sqrt[6]{C_6/\hbar\Omega}$ due to the van der Waals interaction [2].
The Rydberg excitation is proven to be coherent despite strong interactions with a rotary echo technique known from nuclear magnetic resonance physics [3]. The rotary echo experiment was done for various densities of ground state atoms and excitation times, giving insight into the dephasing caused by the van der Waals interaction.

References

[1]R. Heidemann, *et al.*, arXiv:0710.5622 (2007)
[2]R. Heidemann, *et al.*, Phys. Rev. Lett. **99**(16), 163601(2007)
[3]U. Raitzsch, *et al.*, arXiv:0706.3869 (2007)

A 19.2 Do 8:45 2G

Universal Scaling in a Strongly Interacting Rydberg gas — •Hendrik Weimer[1], Hans Peter Büchler[1], Rolf Heidemann[2], Ulrich Raitzsch[2], Vera Bendkowsky[2], Björn Butscher[2], Robert Löw[2], and Tilman Pfau[2] — [1]Institut für Theoretische Physik III, Universität Stuttgart — [2]5. Physikalisches Institut, Universität Stuttgart

We analyze the van der Waals blockade and the quantum evolution of an atomic gas resonantly driven by a laser into a strongly interacting Rydberg state. Such a system has recently been studied experimentally by Heidemann et al. [1]. The main mechanism behind the van der Waals blockade is that once a Rydberg atom is excited, the van der Waals interaction shifts the surrounding atoms out of resonance with the driving laser and therefore suppresses the excitation of additional Rydberg atoms. The combination of the van der Waals interaction with the Rabi frequency of the resonant laser gives rise to a single dimensionless parameter. We show that the experimental data exhibits a data collapse with a universal scaling function in this single dimensionless parameter. A numerical analysis of the effective theory provides

excellent agreement for the scaling function with the experiment, and is evidence for universality in a strongly interacting Rydberg gas undergoing coherent quantum evolution.

[1] R. Heidemann et. al. Phys. Rev. Lett. **99**, 163601 (2007).

A 19.3 Do 9:00 2G

Many-particle mechanical effects of an interacting Rydberg gas — •Thomas Amthor, Markus Reetz-Lamour, Christian Giese, and Matthias Weidemüller — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Gases of ultracold Rydberg atoms have been found to spontaneously ionize and form plasmas [1]. Recent experiments showed that the initial ionization is mainly due to collisions induced by long-range forces between the cold Rydberg atoms. 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]. For attractive interaction potentials, atoms excited to Rydberg states on the red-detuned wing of the resonance are observed to ionize first, as more atom pairs are prepared at short distances and experience strong attractive forces. Here we discuss the ionization dynamics of gases initially prepared in states with purely repulsive interaction. This requires a more detailed model including many-particle aspects and mechanisms for state redistribution to overcome the repulsive forces. A Monte Carlo model for the description of such a system is presented and agrees well with experimental observations [4].

[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. 98, 023004 (2007)
[4] T. Amthor et al., Phys. Rev. A 76, 054702 (2007)

A 19.4 Do 9:15 2G

Prospects for resonant energy transfer in structured ultracold Rydberg gases — •Christian Giese, Christoph Sebastian Hofmann, Wendelin Sprenger, Janne Denskat, Thomas Amthor, Markus Reetz-Lamour, and Matthias Weidemüller — Physikalisches Intitut, Universität Freiburg, Hermann-Herderstr. 3, 79104 Freiburg

Dynamics in cold Rydberg gases are entirely determined by long-range dipole-dipole and van der Waals interactions due to the negligible translational energy. A unique feature of the system is the tunability of these interactions in both strength and character. In this manner, two Rydberg pair states can be made energetically degenerate. This leads to energy and population transfer known as resonant energy transfer (RET) which plays an important role in the process of photosynthesis. In recent work , we have compared Monte Carlo simulations of this process to density dependent population measurements[1]. Coherent energy transfer occurs, but the signature is washed out by many-body diffusion and disorder. To overcome this, we plan to use beamshaping techniques for structuring the atomic cloud. Recently, the theoretical and experimental prospects of coherent exciton transport in linear chains in the presence of excitation traps were discussed[2]. We propose an experimental way of using cold, structured Rydberg gases as a model system for investigating the coherent and incoherent properties of this process when introducing different degrees of disorder.

[1] S. Westermann et al., Eur. J. Phys. D 40, 37 (2006)
[2] O. Mülken et al., Phys. Rev. Lett. 99, 090601 (2007)

A 19.5 Do 9:30 2G

High-resolution spectroscopy of an ultracold Rydberg gas — •Christoph S. Hofmann, Thomas Amthor, Christian Giese, Wendelin Sprenger, Markus Reetz-Lamour, and Matthias Weidemueller — Physics Institute, Albert-Ludwig University Freiburg, 79104 Freiburg, Germany

The exaggerated properties of Rydberg atoms provide a fertile ground for investigating atomic interaction phenomena. Due to the long-range character of the interaction between highly excited atoms, the dynamics of an ultracold gas of Rydberg atoms are entirely determined by van-der-Waals and dipole-dipole interactions. Rydberg excitation-spectra reveal valuable information over a wide range of characteristic phenomena occurring in ultracold Rydberg samples, which are the scope of this talk. For instance, effects like suppression of excitation due to Rydberg-Rydberg interaction [1] can be traced back by analysing these spectra. Spectral features such as line shapes and broadening provide information on interaction potentials. Furthermore highly resolved spectra also permit the observation of long-range molecular resonances [2]. High-resolution spectroscopy requires sophisticated experimental techniques like careful electric and magnetic stray field control, frequency stabilized excitation and probe lasers with narrow line widths as well as sensitive ion detection schemes. An overview about these techniques is given in this talk.

[1] D. Tong et al.,Phys. Rev. Lett. 93, 063001 (2004); K. Singer et al., Phys. Rev. Lett. 93, 163001 (2004)
[2] S. M. Farooqi et al., Phys. Rev. Lett. 91, 183002 (2003)

A 19.6 Do 9:45 2G

Rydberg excitations in an Ion Trap — •Igor Lesanovsky[1], Markus Müller[1], Lin-Mei Liang[1,2], and Peter Zoller[1] — [1]Institute for Theoretical Physics, University of Innsbruck, and Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, Innsbruck, Austria — [2]Department of Physcis, National University of Defense Technology, Changsha 410073, China

We investigate Rydberg excitations of ions which are trapped in a linear Paul trap. In such trap the ions are confined by an electric quadrupole field and a ponderomotive potential due to an oscillating quadrupole. We employ a two-body approach in order to model the Rydberg ions and derive the Hamiltonian governing Rydberg excitations in a linear ion crystal. We show how a strong state-dependent dipole-dipole interaction among the ions can be achieved by coupling Rydberg states of different parity using a microwave field. This system offers the possibility to study Rydberg excitation dynamics of a mesoscopic ensemble in a structured environment and permits the experimental realization of strongly interacting spin models.

A 20: Experiments with FLASH and FEL perspectives: an overview

Zeit: Donnerstag 11:00–13:00 Raum: 3C

Hauptvortrag A 20.1 Do 11:00 3C

On the path towards table-top free-electron-lasers — •Florian Gruener[1], Matthias Fuchs[2], Raphael Weingartner[2], Benjamin Marx[2], Stefan Becker[2], and Dieter Habs[2] — [1]Max-Planck Institute of Quantum Optics, Garching, Germany — [2]University of Munich, Munich, Germany

One of the key projects within the Cluster of Excellence "Munich-Centre for Advanced Photonics" (MAP) is the realization of a table-top free-electron-laser (FEL). In general, FELs are the world's most brilliant light sources allowing totally new experiments, such as "4D imaging" in the X-ray range like single molecule imaging. Owing to the immense size and costs, world-wide only a few X-ray FELs are planned and only a few VUV FELs are in operation. These large-scale FELs are based upon conventional electron accelerators. In contrast, we propose to utilize laser-plasma accelerated electrons with their unprecedented high peak currents. In principle this allows to shrink the size of an FEL down to meter-scale instead of tens or hundred of meters. In this talk the principle possibility is discussed as well as the milestones planned on the path towards the first proof-of-principle experiment. The potential of such future table-top FELs is immense as their smaller size and higher photon energies reachable than in case of large-scale XFELs would even allow the usage in hospitals for medical diagnostic (such as phase-contrast imaging for mammography). We also address applications in nuclear physics.

A 20.2 Do 11:30 3C

Two-photon ionization of neon at 91 eV photon energy — •Ulrike Frühling[1], Marek Wieland[2], Elke Plönjes-Palm[1], Michael Gensch[1], and Markus Drescher[2] — [1]Desy, Hamburg — [2]Universität Hamburg

For measurement of the temporal properties of optical pulses the nonlinear response of an optical medium on two optical fields of different or the same color is often used to realize cross- or autocorrelation schemes. The observation of nonlinear processes e.g. multiphoton-ionisation in-

duced by short-pulse coherent extreme ultraviolet (XUV) radiation opens up the possibility of applying these correlation techniques in the XUV range. We have studied two-photon ionization of neon by photoelectron spectroscopy at the soft-x-ray free-electron laser in Hamburg (FLASH). The photon energy was 91 eV. The XUV-beam was focused using a multilayer mirror to irradiance levels of up to $10^{14} W/cm^2$, leading to features in the electron spectrum which can be attributed to nonlinear processes.

A 20.3 Do 11:45 3C

Atoms in the focus of an extreme-ultraviolet laser — •Mathias Richter[1], Andrei A. Sorokin[1,2], Kai Tiedtke[3], and Hubertus Wabnitz[3] — [1]Physikalisch-Technische Bundesanstalt, Abbestraße 2-12, 10587 Berlin, Germany — [2]Ioffe Physico-Technical Institute, Polytekhnicheskaya 26, 194021 St. Petersburg, Russia — [3]Deutsches Elektronen-Synchrotron, Notkestraße 85, 22603 Hamburg, Germany

First investigations at the new Free-electron LASer in Hamburg FLASH [1] on rare gases have shown that multiphoton ionization at photon energies above ionization thresholds is dominated by sequential processes via ionic states [2]. However, in a recent work on xenon atoms, irradiance levels of more than 1000 terawatt per square centimeter were achieved at a photon energy of 93 electron volts by microfocusing of the FLASH beam with the aid of a spherical extreme-ultraviolet multilayer mirror [3]. Although these experiments were performed within the regime of the classical photoelectric effect, explanation of the unexpected high degrees of photoionization observed seems to be beyond the scope of the perturbation theory and photons as the light particles. As an extension of this study, we present and discuss, here, also new results on the generation of Li-like neon under similar conditions.

[1] W. Ackermann et al., Nature Photonics 1, 336 (2007)
[2] A. A. Sorokin et al., Phys. Rev. A 75, 051402(R) (2007)
[3] A. A. Sorokin et al., Phys. Rev. Lett. 99, 213002 (2007)

A 20.4 Do 12:00 3C

Xe clusters in intense laser pulses of the FLASH FEL: on vs. below 4d innershell resonance excitation — •Heiko Thomas[1], Christoph Bostedt[1], Matthias Hoener[1], Ekaterina Eremina[1], Thomas Möller[1], Hubertus Wabnitz[2], and Rolf Treusch[2] — [1]IOAP - Technische Universität Berlin — [2]Hasylab at DESY

The interaction of rare gas clusters with intense vacuum ultraviolet radiation from the DESY free electron lasers has yielded many surprising results. In first experiments performed with 100 nm radiation at power densities up to 10^{13} W/cm^2 the clusters disintegrated completely in a strong Coulomb explosion and kinetic energies of the resulting ions up to a few keV were measured.

We have investigated the interaction of intense light pulses from the FLASH - FEL below (32 nm) and in (13 nm) the Xe giant 4d resonance at power densities up to 10^{15} W/cm^2. The data show for resonant excitation significantly higher charge states and higher kinetic energies of the ions leaving the cluster. However, both experiments at short wavelength exhibit lower energy absorption compared to the previous investigations at 100 nm. In addition to the wavelength dependence, the data will be discussed in terms of cluster size and laser intensity.

A 20.5 Do 12:15 3C

Ultrafast imaging of clusters with intense soft - ray pulses from the FLASH - FEL — •Christoph Bostedt[1], Ekaterina Eremina[1], Daniela Rupp[1], Markus Adolph[1], Heiko Thomas[1], Matthias Hoener[1], Hubertus Wabnitz[2], Rolf Treusch[2], and Thomas Möller[1] — [1]IOAP - Technische Universität Berlin — [2]Hasylab at DESY

Intense, short laser pulses in the x-ray regime from free-electron lasers (FELs) hold great promise for future single-shot imaging experiments on individual molecules. We have performed first scattering experiments on atomic clusters with $\lambda = 13$ nm laser pulses at intensities up to 10^{14} W/cm^2 from the FLASH-FEL at DESY in Hamburg. The data shows clear diffraction patterns for single cluster, two-cluster, and double-cluster events. Comparing the scattering data to classical Mie theory unveils distinct differences for the depth of the minima and the slope of the data which can be attributed to the changing optical constants of the cluster in an intense laser pulse and softening of the cluster edge due to the onset of Coulomb explosion. Further, the possibility of probing transient plasma properties through scattering experiments with atomic clusters is discussed.

A 20.6 Do 12:30 3C

Untersuchung von Mehr-Photonen-Prozessen in Edelgasen mit winkelauflösender Photoelektronenspektroskopie am FLASH — •Markus Braune[1], Axel Reinköster[1], Jens Viefhaus[2], Bernd Lohmann[3] und Uwe Becker[1] — [1]Fritz-Haber-Institut der MPG, 14195 Berlin — [2]DESY, 22607 Hamburg — [3]Universität Münster, 48149 Münster

Mit winkelauflösender Photoelektronenspektroskopie wurden in Experimenten bei FLASH Mehr-Photonen-Ionisationsprozesse verschiedener Edelgase untersucht. Man beobachtet intensive sequentielle und etwa 100mal schwächere simultane Ionisationsprozesse, deren Zwischen- und Endzustände anhand der Photoelektronenenergien unterschieden werden können. Besondere Bedeutung hat die Analyse der Abhängigkeit der Signalstärke von der Lichtintensität und der Winkelverteilung der Photoelektronenemission dieser Prozesse. In den Intensitätsverläufen zeigt sich die Abhängigkeit der nachfolgenden Prozesse von der Erzeugung des ionischen Targets durch die Primärionisation. Die Winkelverteilungen der Photoemission enthalten Anteile höherer Ordnungen und weichen von einer reinen Dipolverteilung ab, welche nur von einem Parameter β_2 bestimmt ist. Der entsprechenden Parameter β_4 der höheren Ordnung kann bestimmt und mit neuesten theoretischen Rechnungen verglichen werden. Durch Messungen dieser Art werden systematische Studien verschiedener Ionisationsstufen des Targets und die Wechselwirkung zwischen simultanen und sequentiellen Prozessen möglich. Ergebnisse von den jüngsten Experimenten werden vorgestellt.

A 20.7 Do 12:45 3C

From Fission to Explosion: a Momentum Resolved Survey over the Rayleigh Instability Barrier — •Matthias Hoener[1], Sebastian Schorb[1], Heiko Thomas[1], Lutz Foucar[2], Thomas Möller[1], and Christoph Bostedt[1] — [1]IOAP, TU Berlin, Germany — [2]IKP, Uni Frankfurt a.M., Germany

We investigated the fragmentation processes of Ne (liquid)- and Xe (solid)-clusters with a momentum resolving reaction microscope. Irradiating different sized clusters with different excitation energies leads through Auger decays to a distinct amount of average charge on the clusters. Through variation of inner coulombic energy (E(coul)) and surface tension (E(sur)) we can set the fissility X of the the system (X=E(coul)/2E(sur)) based on the liquid trop model (LDM) for macroscopic particles. The fissility determines the scenario of fragmentation: X < 1, non-isotropic fission into a few large, less energetic ions, X > 1, isotropic explosion into many small, energetic ions. The COLTRIMS system enables us to detect all generated ionic fragments in a momentum resolved manner. In this way we can determine the three dimensional fragmentation geometry in dependance of X and the phases of the clusters. Both, the fragmentation pattern of liquid Ne- and solid Xe-clusters, show a very different behavior for the two regimes. The clusters show for X < 1 a fission-like behavior and for X > 1 an explosion-like behavior in qualitative agreement with the LDM. However, the data show a strong correlation of the fragmentation with the cluster phase.

A 21: Atomic systems in external fields

Zeit: Donnerstag 11:00–13:00 Raum: 3D

Hauptvortrag A 21.1 Do 11:00 3D

Helium und die Tripelkollision - neue Skalierungsgesetze in Zweielektronenatomen — Chang Woo Byun[1], Nark Nyul Choi[1], Min-Ho Lee[1] und •Gregor Tanner[2] — [1]School of Natural Science, Kumoh National Institute of Technology, Korea — [2]School of Mathematical Sciences, University of Nottingham, UK

Im Jahre 1940 untersuchte Carl Ludwig Siegel den Dreierstoss (bzw die Triplekollision) im Detail und fuehrte die Dynamik in der Naehe der Kollision auf charakteristische Exponenten zurueck. Etwa ein Jahrzehnt spaeter nutzte Gregory H Wannier aehnlich Methoden um

die Energieabhaengigkeit des Wirkungsquerschnitts fuer den Dreiteilchenaufbruch in Atomen vorherzusagen.

Wir werden in diesem Beitrag demonstrieren, dass uns Siegels Exponenten in Zweielektronenatomen oberhalb und unterhalb (!) der Doppelionisationsschwelle auf Schritt und Tritt begegnen - nicht nur in der von Wannier angegebenen Kombination. Wir werden insbesondere totale und partielle Wirkungsquerschnitte fuer Einfach- Photoionisation an der Dreiteilchenaufbruchschwelle behandeln und Mithilfe semiklassischer Methoden charakteristische Skalierungsgesetze herleiten. Dies ermoeglicht es grundlegende Aussagen ueber doppelt hochangeregte Zustaende und ihre Zerfallskanaele an der Schwelle zu machen.

C L Siegel, 'Der Dreierstoss', Ann of Math 42, 127 (1941)
G H Wannier, Phys Rev 90, 817 (1953)
C W Byun et al, Phys Rev Lett 98, 113001 (2007)

A 21.2 Do 11:30 3D

Non-hydrogenic Rydberg atoms in crossed electric and magnetic fields — •Celsus Bouri[1], Javier Madroñero[2,3], Thomas Gorin[4], and Andreas Buchleitner[1] — [1]Quantum Optics and Statistics, Institute of Physics, Albert-Ludwigs-Universität Freiburg, Freiburg, Germany — [2]PAMO, Université Catholique de Louvain, Louvain-la-Neuve, Belgium
— [3]Physik Department, Technische Universität München, Garching, Germany
— [4]Departamento de Física, Universidad de Guadalajara, Guadalajara, Mexico

Fluctuations of the ionization cross section for non-hydrogenic Rydberg atoms in crossed electric and magnetic fields are considered - in a regime where strongly overlapping resonances dominate the fragmentation process. We address some open issues concerning the identification of this scenario as an examplary case of Ericson fluctuations in a deterministic Hamiltonian systems - which stem from the multielectron core as well as from the mixedness and high dimensionality of the underlying classical phase space.

A 21.3 Do 11:45 3D

Complex electron dynamics in integrable systems — •Tobias Kramer[1], Christian Bracher[2], and John Delos[3] — [1]Institut I: Theoretische Physik, Universität Regensburg, Germany — [2]California State University, Long Beach, USA — [3]College of William and Mary, Williamsburg, USA

The classical dynamics of photoionization and detachment in the presence of external fields is in general very complex, even for integrable systems. The corresponding quantum mechanical cross section and spectra show strong fluctuations due to interference of returning orbits. We present analytic classical and quantum mechanical results for atoms in magnetic and electric fields which allow to study in detail sequences of bifurcation points, caustics, and failures of a primitive semiclassical expansions. The statistical analysis of the spectrum shows that classical chaotic and integrable systems are not always distinguishable by looking at spectral correlation functions.

References:

[1] Electron dynamics in parallel electric and magnetic fields C. Bracher, T. Kramer, and J. Delos Phys. Rev. A, 73, 062114-1-21, (2006)

A 21.4 Do 12:00 3D

Quantum Monte Carlo studies of heavy atoms in neutron-star magnetic fields — •Dirk Meyer, Steffen Bücheler, Dirk Engel, Jörg Main, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart, 70550 Stuttgart

We have adapted the "released-phase"diffusion quantum Monte Carlo method to calculate the ground state energies of atoms and ions with nuclear charges from $Z = 2, 3, 4, \cdots, 26$ for magnetic field strengths relevant for neutron stars [1]. The novel feature of our study is the use of adiabatic approximation wave functions, augmented by a Jastrow factor, as guiding wave functions to initialize the quantum Monte Carlo prodecure. The calculations are motivated by the discovery of broad features in the thermal spectra of isolated neutron stars, which may be due to heavy atoms. Our results confirm previous results for nuclear charge numbers up to 10, and are the most accurate ones available in the literature to date for $Z > 10$. We also discuss the extension of the calculations to excited states and transition probabilities by using the correlation function Monte Carlo method [2].

[1] S. Bücheler, D. Engel, J. Main, and G. Wunner, Phys. Rev. A **76**, 032501(2007)
[2] M. D. Jones, G. Ortiz, and D. Ceperley, Phys. Rev. E **55**, 6202 (1997)

A 21.5 Do 12:15 3D

Evidence for quasi Penning resonances in exact quantum spectra of the hydrogen atom in crossed electric and magnetic fields — •Holger Cartarius, Jörg Main, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart, 70550 Stuttgart

The ionization mechanism of the hydrogen atom in crossed magnetic and electric fields has been investigated, e.g. by application of transition state theory [1], however, a complete physical picture is still lacking. In particular, the existence of transition states localized in the vicinity of the Stark saddle point or so-called "quasi Penning resonances" [2] obtained by quantization using a simple expansion of the potential around the saddle point is unclear. We perform quantum mechanically exact calculations of resonances in the spectrum of the hydrogen atom in crossed external fields. By varying the external field strengths structures are revealed which are surprisingly similar to quasi Penning resonances. We investigate the connection between the approximate solutions and the exact quantum resonances.

[1] C. Jaffé, D. Farrelly, and T. Uzer, Phys. Rev. Lett. **84**, 610 (2000); Phys. Rev. A **60**, 3833 (1999)
[2] C. W. Clark, E. Korevaar, and M. G. Littman, Phys. Rev. Lett. **54**, 320 (1985)

A 21.6 Do 12:30 3D

The Installation of the HITRAP Cooler Trap — Frank Herfurth[1], Oliver Kester[1], Heinz-Jürgen Kluge[1], •Stephen Koszudowski[1], Christophor Kozhuharov[1], Giancarlo Maero[1], Wolfgang Quint[1], and Stefan Schwarz[2] — [1]GSI, 64291 Darmstadt, Germany — [2]NSCL/MSU, East Lansing, USA

With the HITRAP facility the means are given to trap and cool heavy highly charged ions up to U92+ in order to perform experiments on atomic properties. These include collision studies, precision measurements and hyperfine spectroscopy. Within the Cooler Trap 10e5 particles will be cooled by electron and resistive cooling down to 4K. the particles in the trap will be detected nondestructively by FT-ICR. Right now the Cooler Trap is being installed at GSI. We give a status overview and show results of the commissioning.

A 21.7 Do 12:45 3D

Particle motion in rapidly oscillating potentials: The role of the potential's initial phase — •Armin Ridinger[1] and Nir Davidson[2] — [1]Laboratoire Kastler Brossel, Ecole Normale Supérieure, Université Pierre et Marie-Curie-Paris 6, CNRS — [2]Department of Physics of Complex Systems, Weizmann Institute of Science, Rehovot 76100, Israel

Rapidly oscillating potentials with a vanishing time average have been used for a long time to trap charged particles in source-free regions. It has been argued that the motion of a particle inside such a potential can be approximately described by a time independent effective potential, which does not depend upon the initial phase of the oscillating potential. However, we show that the motion of a particle significantly depends upon this initial phase for arbitrarily high frequencies of the potential's oscillation. We demonstrate that this phenomenon can be used to manipulate a particle's motion in a controlled fashion by simply changing the phase of the potential (a phase hop). For a particle in an ideal one-dimensional Paul-trap we show that a phase hop can—in the framework of classical mechanics—reduce the particle's energy to less than 30% of its original energy independently of its original energy and the frequency of the potential's oscillation. We confirm all our theoretical findings by numerical simulations.

Reference: A. Ridinger and N. Davidson, Phys. Rev. A 76, 013421 (2007).

A 22: Collision processes and energy transfer II (jointly with MO)

Zeit: Donnerstag 11:00–12:15 Raum: 3F

Gruppenbericht A 22.1 Do 11:00 3F

High-resolution electron collision spectroscopy of the elementary second-row molecular ions — •O. Novotny[1], M.H. Berg[1], D. Bing[1], H. Buhr[1,2], H. Fadil[1], M. Froese[1], J. Hoffmann[1], A.S. Jaroshevich[3], B. Jordan-Thaden[1], C. Krantz[1], M. Lange[1], M. Lestinsky[1], M.B. Mendes[1], S. Novotny[1], D.A. Orlov[1], A. Petrignani[1], S. Reinhardt[1], T. Sorg[1], and A. Wolf[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany — [2]Department of Particle Physics, Weizmann Institute of Science, Rehovot 76100, Israel — [3]Institute of Semiconductor Physics, 630090 Novosibirsk, Russia

The fundamental molecules composed of atoms from the second row of the periodic table (C,N,O,F) have a rich structure of excited potential curves that can be probed at high energy resolution by observing fragmentation processes following collisions with quasi-monochromatic electrons. Experiments of this type are performed in merged electron and ion beams at the ion storage ring TSR in Heidelberg. Using a cold, photocathode-produced electron beam, experiments on the system CF^+ yield rich structure in the collision energy dependence of both dissociative recombination and excitation. Moreover, the final atomic levels reached in the fragmentation can be observed, shedding light on their correlation to the collisionally populated excited molecular potentials.

A 22.2 Do 11:30 3F

Relativistic and non-relativistic LDA, benchmark results and investigation on the dimers Cu_2, Ag_2, Au_2, Rg_2. — •Ossama Kullie — University of Kassel, Department of Natural Science, Institute of Physics

Using two spinor minimax method combined with finite element methods accompanied with extrapolation and counterpoise techniques enable us to obtain relativistic highly accurate results for two atomic molecules. Like in our previous work for the (Hartree-) Dirac-Fock-Slater (DFS) functional approximation, we investigate in this work the density functional approximations of the relativistic and nonrelativistic local-density functional, presenting highly accurate benchmark results of chemical properties on the dimers of the group 11(Ib) of the periodic table of elements. The comparison with DFS, with experimental and literature's results shows that DFS is better behaved than the other two local functionals.

1-O. Kullie, H. Zhang and D. Kolb, submiited to Chem. Phys.. (2007)
2-O. Kullie, H. Zhang, J. Kolb and D. Kolb, J. Chem. Phys. **125**, 244303 (2006)

A 22.3 Do 11:45 3F

Semiclassical treatment of non-Markovian dissipative quantum dynamics — •Werner Koch[1], Frank Grossmann[1], Jürgen Stockburger[2], and Joachim Ankerhold[2] — [1]Institut für Theoretische Physik, Technische Univeristät Dresden, 01062 Dresden — [2]Institut für Theoretische Physik, Universität Ulm, Albert-Einstein-Allee 11, 89069 Ulm

Any realistic system is coupled to its environment even if this coupling is very weak. The influence of the environment can result in dissipation of energy as well as decoherence of states in the system. Both effects have to be taken into account to accurately describe the time evolution of a state prepared in the system. A model system for the study of these effects is a single oscillator, linearly coupled to a bath of oscillators with a fixed temperature. The dynamics of the heat bath is treated using the influence functional formalism [1]. We show numerical results for the system under the influence of the heat bath using semiclassical techniques in initial value representation [2]. Issues arising during such calculations are discussed.

[1] Feynman, R. P. & Vernon, F. L.. "The theory of a general quantum system interacting with a linear dissipative system." Annals of Physics, no. 24 (1963): 118-173.

[2] Herman, M. F. & Kluk, E.. "A semiclassical justification for the use of nonspreading wavepackets in dynamics calculations." Chemical Physics, vol. 91 (1984): 27-34

A 22.4 Do 12:00 3F

A systematic study of the beta-decay properties — •Ivan Borzov[1], Jose Cuenca-García[1], Karlheinz Langanke[1], Gabriel Martínez-Pined[1], and Fernando Montes[2] — [1]GSI, Darmstadt, Plankstr. 1, D-64291, Darmstadt, Germany — [2]National Superconducting Cyclotron Lab., Michigan State University, East Lancing, MI 48824, USA

A self-consistent approach to the nuclear ground states and spin-excitations based on the local energy-density functional (DF) theory and continuum QRPA is presented. Systematic calculations of the total β-decay rates for the nuclei with charge numbers Z=24-31, 42-49, 72-78, 82-89 approaching the possible r-process paths in vicinity of the spherical neutron shells at N=50, 82, 126 are calculated and compared with the experimental data. When available, the half-lives obtained on the basis of the Finite Range Droplet Model and the shell model are compared to our results. The effects of our calculated half-lives on the r-process abundances in the A=90-130 mass region are explored in r-process simulations.

1.J.J. Cuenca- Garcia, G. Martinez-Pinedo, K. Langanke, F. Nowacki, I.N. Borzov, 2007, Eur.J.Phys. epja/i2007-10477-3. 2.Kurtukian-Nietto T., Benluire J, and GSI Collaboration First access to beta half-lives approaching the r-process path near N=126., 2007, (submitted to Phys. ReV. Lett); nucl-ex 0711.0101. 3.I.N. Borzov, J.J. Cuenca- Garcia, G. Martinez-Pinedo, K. Langanke, F. Montes, 2007, (submitted to Nucl.Phys. A).

A 23: Precision spectroscopy II

Zeit: Donnerstag 14:00–16:00 Raum: 3C

A 23.1 Do 14:00 3C

Design of a stable battery-based voltage — •Anke Wagner[1], Klaus Blaum[1,2], Wolfgang Quint[2], Birgit Schabinger[1], and Sven Sturm[1] — [1]Institute of Physics, Johannes Gutenberg-University, 55099 Mainz, Germany — [2]GSI Darmstadt, 64291 Darmstadt, Germany

For the high-precision measurement of the magnetic moment of the electron bound in highly-charged hydrogen-like calcium ions highly stable voltage sources are needed. [1] For those again a very stable supply voltage is required, which has to be independent of the electricity network in order to avoid noise and ground loops. Therefore, a battery-based voltage source was designed. Only one car-battery (12V) was used to generate the required output voltages (±15V, ±5V) by converting the dc-voltage into ac-voltage, amplifying, commutating and, finally, flattening it again. To control and monitor the voltages as well as the currents, a microcontroller, connected to the PC, is used. The circuit diagrams and the achieved voltage stability will be presented.

[1] M. Vogel *et al.*, Nucl. Inst. Meth. B **235**, 7 (2005)

A 23.2 Do 14:15 3C

Simulation of the dynamics of a cloud of highly-charged ions in a Penning trap for the HITRAP project — •Giancarlo Maero[1], Irene Chiarelli[1], Frank Herfurth[1], Oliver Kester[1], H.-Jürgen Kluge[1], Stephen Koszudowski[1], Wolfgang Quint[1], and Stefan Schwarz[2] — [1]GSI Darmstadt, Germany — [2]MSU, East Lansing, USA

Atomic physics investigations on cold, highly-charged ions will be possible in the next years at HITRAP, the GSI facility for the deceleration of heavy, highly-charged ions up to U^{92+}. Bunches of 10^5 ions will be trapped and cooled down to 4 K in the cooler Penning trap via electron and resistive cooling. A Particle-In-Cell (PIC) code has been developed to study the dynamics of the ion cloud during the cooling process. The challenges were the incorporation of the strong magnetic field and the implementation of the resistive cooling mechanism for a cloud of interacting ions. We discuss the results with emphasis on the space charge effects and the resistive cooling technique.

A 23.3 Do 14:30 3C

Inbetriebnahme und Status von HITRAP — •Oliver Kester, Ludwig Dahl, Frank Herfurth, Heinz-Jürgen Kluge, Christophor Kozhuharov, Wolfgang Quint und Thomas Stöhlker für die HITRAP-Kollaboration — GSI Darmstadt, Planckstrasse 1, D-64291 Darmstadt

An der GSI Darmstadt wird seit 2005 die "Highly charged Ion Trap"(HITRAP) Anlage aufgebaut. HITRAP dient zum Abbremsen, Einfangen und Kühlen hochgeladener schwerer Ionen bis zu nacktem Uran und soll Experimente mit solchen hochgeladenen Ionen mit extrem niederigen kinetischen Energien bedienen. Die Experimente an HITRAP umfassen unter anderem Präzisions- und Laserspektroskopie in Penningfallen, neuartige Studien zur Wechselwirkung von Ionen mit Oberflächen, sowie Stossexperimente mit vollständiger kinematischer Analyse. Die erste Sektion des HITRAP Linearbeschleunigers, welche die beiden Buncher Strukturen umfasst, ist in 2007 aufgebaut und mit Strahlen aus dem ESR getestet worden. Sämtliche Strahllinien-Komponenten bis zur Kühler-Penningfalle stehen zur Verfügung und werden sukzessive in die Strahllinie eingebaut. In 2008 werden die Kühler-Penningfalle, welche das Einfangen und Kühlen der hochgeladenen Ionen übernimmt und die restlichen Beschleunigerstrukturen in Betrieb genommen werden. Parallel dazu läuft der Aufbau der verschiedenen Experimente. Ergebnisse der Inbetriebnahme, der Status von HITRAP und die Vorbereitungen für die Experimente sollen vorgestellt werden.

A 23.4 Do 14:45 3C

A non-destructive detection of highly-charged ions for the measurement of the magnetic moment of the bound electron in ^{40,48}Ca$^{17+,19+}$ — •Sven Sturm[1], Klaus Blaum[1,2], Wolfgang Quint[2], Birgit Schabinger[1], Anke Wagner[1], and Günter Werth[1] — [1]Institute of Physics, Johannes Gutenberg-University, 55099 Mainz, Germany — [2]GSI Darmstadt, 64291 Darmstadt, Germany

The high-precision measurement of the magnetic moment of the bound electron in highly-charged ions yields a stringent test for Bound-State quantum electrodynamical (BS-QED) calculations. Since the BS-QED contribution to the g-factor calculation increases with the nuclear charge, we plan to measure the g-factor of ^{40,48}Ca$^{17+,19+}$ ions stored in a triple-Penning trap system with a relative uncertainty of 10^{-9} using the "continuous Stern-Gerlach-effect" [1]. To this end, a novel Penning trap setup and highly sensitive detection methods at cryogenic temperatures have been developed and tested. The principle of the non-destructive detection technique for multi-species ion-clouds as well as single ions is introduced and recent results are presented.
[1] M. Vogel *et al.*, Nucl. Inst. Meth. B **235**, 7 (2005)

A 23.5 Do 15:00 3C

X-Ray Transitions from Antiprotonic Noble Gases — Detlev Gotta[1], •Khalid Rashid[2], Burkhard Fricke[3], Paul Indelicato[4], and Leon Simon[5] — [1]Institut für Kernphysik, Forschungszentrum Jülich, D-52425 Jülich, Germanny — [2]Bahria University, E-8, Islamabad, Pakistan — [3]Institut für Physik, Universität Kassel, D-34132 Kassel, Germany — [4]Laboratoire Kastler Brossel, UPMC-Paris 6 ENS CNRS; Case 74, 4 Place Jussieu, F-75005 Paris, France — [5]Laboratory for Particle Physics, Paul Scherer Institut, CH-5232 Villingen, Switzerland

The onset of antiprotonic X-ray transitions at high principal quantum numbers and the occurrence of electronic X-ray in antiprotonic argon krypton, and xenon is analysed with Multiconfiguration Dirac-Fock calculations. The shell by shell ionisation by Auger electron emission, characterised by appearance and disappearance of X-ray lines, is followed through the antiprotonic cascade by considering transition and binding energies of both the antiproton and remaining electrons. A number of additional lines in the X-ray spectra have been tentatively assigned to electronic transitions caused by electronic de-excitation after Auger emission during the antiprotonic cascade. A few lines remain unexplained so far or are not unambiguously assigned. The complexity of the electronic states cannot be resolved with semiconductor detectors. Hopefully, in future high resolution devices like crystal spectrometers and Auger electron spectroscopy at antiproton at GSI will resolve this complexity.

A 23.6 Do 15:15 3C

Precision Measurements of Metastable Hydrogen and Deuterium with a modified Lamb-shift Polarimeter — •M. Westig[1], R. Engels[1], K. Grigoryev[1,2], M. Mikirtychyants[1,2], H. Paetz gen. Schieck[3], F. Rathmann[1], G. Schug[1], H. Stroeher[1], V. Trofimov[2], and A. Vasilyev[2] — [1]Institut für Kernphysik, Forschungszentrum Jülich, Leo-Brandt-Str. 1, 52425 Jülich, Germany — [2]Petersburg Nuclear Physics Institut, Orlova Rosha 2, 188300 Gatchina, Russia — [3]Institut für Kernphysik, Universität zu Köln, Zülpicher Str.77, 50937 Köln, Germany

Precision spectroscopy of hydrogen and deuterium is an established method to test bound state quantum electrodynamics (bsqed). State of the art theoretical atomic physics calculations obtain precise values from bsqed for both atomic systems, which provide a real challenge to experimentalists. We are setting up a spectroscopy experiment for metastable hydrogen and deuterium atoms in the IKP of FZ-Jülich. With a spinfilter as a part of a Lamb-shift Polarimeter, we can prepare metastable atomic beams with a well defined energy in one Zeeman state of the hyperfine structure (hfs). In a high frequency device with $\vec{k}$ perpendicular to the beam axis and surrounded by a magnetic field with variable geometry and strength we can induce selected transitions in the atoms. A precise determination of the $2S_{1/2}(\Delta f \approx 10\text{Hz})$, $2P_{1/2}(\Delta f \approx 1\text{kHz})$ hfs intervall, the classical Lamb-shift ($\Delta f \approx 1$kHz) and relative measurements of the $2S_{1/2}$, $2P_{1/2}$ Breit-Rabi-Diagrams with the same uncertainty in both atoms will be possible. The experimental setup and first results will be presented.

A 23.7 Do 15:30 3C

QED effects in high precision lifetime measurements — •José R. Crespo López-Urrutia, Günter Brenner, Volkhard Mäckel, Sascha W. Epp, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, 69117 Heidelberg

The precision achieved recently in the determination of lifetimes of metastable states by using electron beam ion traps, with total uncertainties of the order of 0.15%, has allowed for the first time to become sensitive to QED contributions to the transition probability, such as the effect of the electron anomalous magnetic moment (0.45% contribution). Electric-dipole forbidden transitions are of particular interest, because of the relatively weak dependence of their line strengths on the radial part of the wave function. By systematically improving the related measurement techniques at the Heidelberg electron beam ion trap, highly accurate results for FeXIV, FeX and ArXIV have been obtained. These values, when compared with the most sophisticated predictions, allow to distinguish between the different models used for the calculation of the transition matrix elements. The lines studied are also the strongest visible coronal lines observed in the Sun, and the exact knowledge of their lifetimes has crucial importance for the determining the parameters of those and other astrophysical plasmas.

A 23.8 Do 15:45 3C

Entwicklung hochsensitiver Radiofrequenzdetektoren zum Nachweis einzelner geladener Teilchen — •Stefan Ulmer[1,2], Klaus Blaum[1,2], Holger Kracke[1], Susanne Kreim[1], Wolfgang Quint[3], Cricia Rodegheri[1], Stefan Stahl[4] und Jochen Walz[1] — [1]Institut für Physik,Universität Mainz, 55099 Mainz — [2]MPI für Kernphysik, 69029 Heidelberg — [3]GSI Darmstadt, 64291 Darmstadt — [4]Stahl Electronics, 57582 Mettenheim

Die Spektroskopie von einzelnen, in einer Penning-Falle gespeicherten Teilchen erfordert die Verwendung von hochsensitiven Radiofrequenzdetektoren. Solche Nachweissysteme bestehen aus Resonatoren hoher Güte und einer nachfolgenden rauscharmen Verstärkerstufe. Durch den Betrieb der Detektoren unter kryogenen Bedingungen und der damit einhergehenden Möglichkeit supraleitende Materialien zu verwenden kann ein hohes Signal zu Rausch Verhältnis erreicht werden. Ein supraleitendes Nachweissystem für die Messung der axialen Frequenz eines in einer Penning-Falle gespeicherten Protons wird vorgestellt. Mit dem freien Resonator wurde eine Güte von 41000, mit angekoppeltem Verstärker von 12000 erreicht. Es wird auf Verlustmechanismen in Resonatoren eingegangen, insbesondere auf die Abhängigkeit der Güte von einem externen Magnetfeld. Ferner werden Studien zum Aufbau von rückkopplungsfreien, rauscharmen Hochfrequenzverstärkern präsentiert.

A 24: Photoionization

Zeit: Donnerstag 14:00–15:30 Raum: 3D

A 24.1 Do 14:00 3D

One-photon two-electron processes in Helium: Unity and diversity — •Celsus Bouri[1,2,3], Laurence Malegat[2], Patricia Selles[2], and Moïse Kwato Njock[3] — [1]Quantum Optics and Statistics, Institute of Physics, Albert-Ludwigs-Universität Freiburg, Hermann-Herder Str.3, D-79104 Freiburg, Germany — [2]LIXAM, Bât. 350, Université Paris Sud, F-91405 Orsay, France — [3]CEPAMOQ, Université de Douala, B.P. 8580, Douala, Cameroon

The *ab-initio* H**R**M-SOW method has established itself as the ideally fit tool to explore the three-body dynamics of the helium atom close to the three-body break-up threshold. Accordingly, it is used here to perform a numerical experiment designed to enlighten the relation between the various competing processes which may occur in the vicinity of the double ionization threshold, be it double excitation, excitation-ionization or double ionization. More precisely, double ionization and ionization-excitation cross sections are produced at 100 meV above the double ionization threshold. The latter, obtained up to as high a level as $n = 50$, are in addition analyzed in terms of spherical and parabolic partial waves in the photoelectron frame. Based on these extensive data, we establish a continuity relation between ionization-excitation and double ionization appropriate to the near threshold, confirm previous qualitative predictions regarding the dominant angular momentum achieved in these near threshold excitation processes, evidence the relation between ionized-excited and doubly excited states, and promote the partial parabolic ionization-excitation cross sections as the optimal observation channels of doubly excited states.

A 24.2 Do 14:15 3D

Photoionization cross sections of helium in two and three dimensions — •Johannes Eiglsperger[1], Javier Madroñero[1,2], Harald Friedrich[1], and Bernard Piraux[2] — [1]Physik Department (T30a), TU München, Germany — [2]Unité de physique atomique, moléculaire et d'optique, UC Louvain, Belgium

We explore the regime of highly doubly excited states in two-electron atoms. Photoionization cross sections of planar helium are calculated for this regime and the fluctuations in these cross sections are discussed. Furthermore, we describe the state-of-the-art of our approach for 3D helium, which combines the complex rotation method with an appropriate expansion of the atom wave function in a basis of products of Coulomb-Sturmian functions of the electron radial coordinates with independent dilation parameters for the two electrons and bipolar harmonics of the angular coordinates.

A 24.3 Do 14:30 3D

Tunnelling-induced Entanglement of Electrons in Molecular Double-Slit Experiments — •A. Reinköster[1], M. Braune[1], S. Korica[1], R. Hentges[1], B. Langer[2], R. Dörner[3], and U. Becker[1] — [1]Fritz-Haber-Institut der MPG, Berlin — [2]Freie Universität Berlin — [3]Institut für Kernphysik, Universität Frankfurt

A system of inversion-symmetric emitters, such as a homonuclear diatomic molecule, is a source of spatial quantum coherence. This coherence is the result of electron tunnelling, where the symmetry-induced energy splitting and corresponding tunnelling time are related by the generalized uncertainty principle between time and energy. Emission of the photoelectron is instantaneous, compared to the tunnelling time, and hence randomly local. It gains its non-locality from the tunnelling process only.

One type of experiments studies the typical electron intensity oscillations in a molecular double-slit experiment. They are caused by the interference between core electrons emitted from CO and N_2 after soft X-ray ionization. The single-particle entanglement generates randomization of the probability that the electron is emitted either from the left or the right site. This gives rise to a coherent, non-localized state. Intramolecular scattering reduces this state into a non-coherent and non-localized state, which appears as an EXAFS-like beating on the oscillation. The complementary entangled state is the coherent localized state, which describes two anti-symmetrically oscillating electron emission patterns. This entangled state may be explored by electron-electron coincidence experiments in the molecule frame.

A 24.4 Do 14:45 3D

Photoionisation und Autoionisation von elektronisch angeregtem, atomarem Singulett-Schwefel — •Mathias Barthel, Roman Flesch und Eckart Rühl — Physikalische und Theoretische Chemie, Fachbereich Biologie, Chemie, Pharmazie, Freie Universität Berlin, Takustr. 3, 14195 Berlin

Die Photoionisation und Autoionisation von elektronisch angeregtem atomarem Singulett-Schwefel S(^{1}D) wird mittels durchstimmbarer, gepulster Vakuum-UV-Strahlung im Anregungsbereich 9-11 eV untersucht. Die Erzeugung freier Schwefelatome erfolgt in der Gasphase durch Photolyse von Kohlenstoffdisulfid (CS_2) mit gepulster Laserstrahlung der Wellenlänge 193 nm, die atomaren Schwefel in den Zuständen ^{3}P und ^{1}D liefert. Die Untersuchung der atomaren Spezies erfolgt mittels Photoionisationsmassenspektrometrie in partiellen Ionenausbeuten, analog zu vorausgehenden Untersuchungen an atomarem Singulett-Sauerstoff [1]. Im Anregungsbereich 9-11 eV werden intensive Resonanzen beobachtet, die sich der Autoionisation von Singulett- und Triplett-Rydbergzuständen des Schwefelatoms zuordnen lassen. Durch Subtraktion von Beiträgen aus S(^{3}P) lassen sich Autoionisationsresonanzen des atomaren Singulett-Schwefels eindeutig identifizieren. Ziel der Experimente ist die quantitative Charakterisierung der Photoionisation des S(^{1}D) im Anregungsbereich der S 3p- und S 3s-Ionisation einschließlich der Bestimmung des absoluten Ionisationsquerschnitts.

[1] R. Flesch, M. C. Schürmann, J. Plenge, H. Meiss, M. Hunnekuhl und E. Rühl, *Phys. Rev. A* **62**, 52723 (2000).

A 24.5 Do 15:00 3D

Entwicklung einer Ionenquelle für die KATRIN-Transportstrecke — •Michael Schöppner für die KATRIN-Kollaboration — Forschungszentrum Karlsruhe

Das Ziel des Karlruher Tritium Neutrino Experiments (KATRIN) ist die absolute Massenbestimmung des Elektron-Antineutrinos mit einer Genauigkeit von 0,2 eV/c^2. Dies geschieht mittels einer hochauflösenden Messung des Endpunktbereichs des Tritium-Beta-Spektrums. Die Zerfallselektronen werden mit Magnetfeldern von der Tritium-Quelle durch die Transportstrecke zum Spektrometer geleitet. Da es sich um eine in Strahlrichtung offene Quelle handelt, besteht die Möglichkeit, dass Tritiumionen bis zum Spektrometer gelangen. Dies würde einen Untergrund produzieren, der die Messung verhinderte. Daher werden die Ionen in der Transportstrecke zurückgehalten.

Die differentielle Pumpstrecke (DPS), der erste Teil der Transportstrecke, wird im März'08 geliefert werden. Das Verhalten von Ionen in der DPS muss vor dem Einsatz bei KATRIN experimentell untersucht werden. Hierfür befindet sich eine Ionenquelle in der Entwicklung, die die Tritium-Quelle imitiert und molekulare Deuterium-Ionen auf einer Fläche von ca. 60 cm^2 produziert. Zu diesem Zweck wird eine großflächige Photokathode mit ultraviolettem Licht bestrahlt; die Photoelektronen werden beschleunigt und ionisieren das Deuteriumgas.

Dieser Vortrag behandelt die Entwicklung und gegenwärtigen Status der Ionenquelle. Dieses Projekt wird durch das BMBF gefördert unter Kennzeichen 05CK5VKA/5.

A 24.6 Do 15:15 3D

Laserresonanzionisations - Spektroskopie an den seltenen Erden Tb, Dy und Ho — •Tina Gottwald[1], Jens Lassen[3], Yuan Liu[2], Christoph Mattolat[1] und Klaus Wendt[1] — [1]Johannes-Gutenberg Universität Mainz, Staudinger Weg 7, D-55128 Mainz — [2]Physics Division, Oak Ridge National Laboratory, Oak Ridge TN, USA — [3]TRIUMF-ISAC Division, 4004 Wesbrook Mall, Vancouver, BC, Canada V6T 2A3

Am Oak Ridge National Laboratory (ORNL) wurden unter Verwendung eines hochrepetierenden Ti:Saphir Lasersystems der Universität Mainz spektroskopische Untersuchungen an den seltenen Erden Tb, Dy und Ho vorgenommen. Hierbei kam die Laserresonanzionisations- Massenspektrometrie (RIMS) zum Einsatz, wobei die Proben der zu untersuchenden Elemente in einer geheizten Laserionenquelle verdampft und mittels resonanter Laserstrahlung angepassten spektralen und zeitlichen Profils ionisiert werden. Für die RIMS an Tb, Dy und Ho konnten effiziente und selektive dreistufige Anregungsschemata mit Übergängen im fundamentalen, verdoppelten und verdreifachten Wellenlängenbereich der Ti:Saphir Laser gefunden werden. Diese schließen im zweiten und dritten Anregungsschritt einige bisher unbekannte Energieniveaus ein. Darüber hinaus wurde eine Vielzahl neuer autoio-

nisierender Zustände detektiert und analysiert.

A 25: Posters: Precision spectroscopy of atoms and ions

Zeit: Donnerstag 16:30–18:30 Raum: Poster C3

A 25.1 Do 16:30 Poster C3

Präzise Messung der Hyperfeinstruktur in hochgeladenen Ionen — •Manuel Vogel, Danyal Winters, Zoran Andjelkovic, Wilfried Nörtershäuser und die SPECTRAP- Kollaboration — Gesellschaft für Schwerionenforschung GSI, Planckstrasse 1, 64291 Darmstadt

In hochgeladenen Ionen wie etwa $^{208}Pb^{81+}$ liegen Übergänge zwischen Niveaus der Hyperfeinstruktur im optischen Bereich oder nahe daran und sind mit Methoden der Laserspektroskopie zugänglich. Wir stellen ein Experiment vor, solche Ionen in einer Penningfalle zu speichern, ihre thermische Bewegung auf 4 Kelvin zu kühlen und ihre Hyperfeinstruktur mit einer relativen Auflösung $\Delta\lambda/\lambda$ von etwa 10^{-7} zu vermessen. Dies stellt eine Verbesserung früherer Experimente um 3 Größenordnungen dar und erlaubt stringente Tests entsprechender QED-Rechnungen. Das Projekt trägt den Namen SPECTRAP und findet statt im Rahmen des HITRAP-Projektes an der GSI Darmstadt. Wir präsentieren die zugrunde liegenden Methoden und den Status des experimentellen Aufbaus.

A 25.2 Do 16:30 Poster C3

Polarization studies on the two–photon decay of hydrogen–like ions — •Andrey Surzhykov[1,2], Thomas Radtke[3], Thomas Stöhlker[4,5], and Stephan Fritzsche[1,4] — [1]Max–Planck–Institut für Kernphysik, Heidelberg — [2]École Normale Supérieure, Paris — [3]Universität Kassel — [4]Gesellschaft für Schwerionenforschung (GSI), Darmstadt — [5]Universität Heidelberg

Since the early days of quantum mechanics, the two–photon decay of hydrogen–like ions has been the subject of intense experimental and theoretical studies. While, however, most investigations in the past dealt with the total transition probabilities, much of today's interest is focused on the energy as well as angular distributions [1] and even on the polarization properties of emitted photons [2]. In the nearest future, for example, the two–photon polarization measurements are likely to be carried out at the GSI facility in Darmstadt. In order to provide theoretical support for these experiments, we present a density matrix formalism for the description of the (linear) polarization of one of the photons measured *in coincidence* with the second one. Based on this formalism and on the relativistic Dirac's equation, detailed polarization calculations are performed for the $2s_{1/2} \to 1s_{1/2}$ and $3d_{5/2} \to 1s_{1/2}$ transitions in neutral hydrogen as well as in hydrogen–like xenon and uranium ions. The results of these computations show a strong dependence on the two–photon decay geometry as well as on the magnetic sublevel population of the excited ionic states.

[1] A. Surzhykov *et al.*, Phys. Rev. A **71** (2005) 022509.
[2] H. Kleinpoppen *et al.*, Phys. Scr. **T72** (1997) 7.

A 25.3 Do 16:30 Poster C3

Relativistic photon polarization studies in the two-photon decay of hydrogenlike systems — •Thomas Radtke[1], Stephan Fritzsche[2], and Andrey Surzhykov[3] — [1]Institut für Physik, Universität Kassel, D-34132 Kassel, Germany — [2]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany — [3]Gesellschaft für Schwerionenforschung (GSI), 64291 Darmstadt, Germany

The two-photon decay of metastable hydrogen and hydrogen-like systems has attracted renewed interest from the early days of quantum mechanics. Since then, many theoretical and experimental studies have been carried out to investigate the total decay rates and angular correlation functions of the emitted photons [1].

In this contribution, we analyze the (linear) polarization correlation of the two simultaneously emitted photons in the $2s_{1/2} \to 1s_{1/2}$ and $3d_{5/2} \to 1s_{1/2}$ decay of hydrogenlike atoms and ions. Our description is based on Dirac's equation and, hence, enables us to explore the relativistic and multipole effects upon the photon polarization. For the decay of hydrogen and hydrogen-like U^{91+} ions, results are shown for the angular dependence of the polarization correlation and are compared to the nonrelativistic dipole approximation.

[1] A. Surzhykov, P. Koval, S. Fritzsche, Phys. Rev. A 71, 022509 (2005)

A 25.4 Do 16:30 Poster C3

One single trapped and laser cooled radium ion: Towards an all-optical atomic clock — •Oscar Versolato, Lotje Wansbeek, Lorenz Willmann, Rob Timmermans, and Klaus Jungmann — KVI, University of Groningen

One single trapped Radium ion is an ideal candidate for an all-optical frequency standard (*clock*). This system provides a long coherence time and tractable systematics. If the ion is laser cooled to the Lamb-Dicke regime, first order Doppler shifts are eliminated. Ultra-narrow transitions in radium ions provide an excellent basis for such a high stability clock, using commercially available semiconductor lasers in the visible regime. In certain odd isotopes of radium, the nuclear electric quadrupole shift is absent [1]. Further, the radium ion is an excellent candidate for a high sensitivity experiment to search for a time variation of the finestructure constant [2].

[1] B.K. Sahoo et al., (to be published) [2] V.A. Dzuba, V.V. Flambaum, Phys. Rev. A 61, 034502 (2000)

A 25.5 Do 16:30 Poster C3

Atomic parity violation in one single trapped radium ion as a probe of electroweak running — •Lotje Wansbeek, Oscar Versolato, Lorenz Willmann, Rob Timmermans, and Klaus Jungmann — KVI, University of Groningen

In a single trapped and laser cooled radium ion we investigate atomic parity violation by probing the differential splitting (*light shifts*) of the 7S and 6D Zeeman levels, which is caused by the interaction of the ion with an off-resonant laser light field. This experiment serves as a low-energy test of the electroweak Standard Model of particle physics. With precision RF spectroscopy and subsequent monitoring of quantum jumps, this splitting can be determined to sub-Hertz accuracy. A proof-of-principle has recently been given for the barium ion, and crucial ideas are being extended to Ra+ which is a superior candidate [1].

[1] J. Sherman et al., Phys. Rev. Lett. 94, 243001 (2005)

A 25.6 Do 16:30 Poster C3

Absolute determination of x-ray transition energies in hydrogen- and heliumlike ions at the Heidelberg EBIT — •Katharina Kubiček[1], Johannes Braun[1], Hjalmar Bruhns[2], José R. Crespo López-Urrutia[1], and Joachim Ullrich[1] — [1]Max-Planck-Institut for Nuclear Physics, Heidelberg, Germany — [2]Columbia Astrophysics Laboratory, New York, USA

Absolute and relative high-precision wavelength measurements on highly charged ions (HCI) using an improved Bond method were carried out at the Heidelberg electron beam ion trap (EBIT). Measuring the Lyman-α_1 transition in Ar^{17+} and "w" ($1s2p\ ^1P_1 \to 1s^2\ ^1S_0$) resonance line in Ar^{16+} resulted in transition energies of 3322.993(16) eV and 3139.588(12) eV. These results are the most precise absolute measurements on transition energies in highly charged ions up to now, with total errors of 5 ppm and 4 ppm. The Lyman-α_1 in S^{15+} and "w"transition energy in S^{14+} yielded 2622.692(27) eV and 2460.629(31) eV . The "w"transition energies were also measured relatively to the Lyman-α_1 transitions. A new method for determination of the Bragg angle making use of two light fiducial beams to determine the incoming direction of the x-rays implemented at the flat crystal spectrometer at our laboratory was applied to increase the precision to the present level.

A 25.7 Do 16:30 Poster C3

Towards Direct Frequency Comb Spectroscopy using Quantum Logic — •Börge Hemmerling, Lukas An der Lan, and Piet O. Schmidt — Institut für Experimentalphysik, Universität Innsbruck, Austria

A possible change of the fine-structure constant over cosmological time scales derived from quasar absorption lines is currently strongly debated. One of the difficulties turns out to be the lack of precise labora-

tory data on transition lines of elements with a complex level structure such as Ti^+ and Fe^+ [1].

We challenge this problem by developing a versatile experimental setup in which spectroscopy ions are sympathetically cooled by magnesium ions in a linear Paul trap. Using quantum logic techniques, initial state preparation and state detection of the spectroscopy ion can be very efficient. Owing to the complex level structure of these spectroscopy ions, repumping from unwanted states is required. We plan to implement this by applying an appropriately tailored optical frequency comb.

We will present the latest status of our experimental setup and simulation results on the expected fluorescence signal from a Ca^+ test candidate. We furthermore present schemes based on quantum logic techniques to interrogate single ions in order to further improve the accuracy of the spectroscopic data.

[1] J. C. Berengut, V. A. Dzuba, V. V. Flambaum, M. V. Marchenko and J. K. Webb, arXiv:physics/0408017 (2006)

A 25.8 Do 16:30 Poster C3

Two–photon decay rates for highly–excited ionic states — •Andrey Surzhykov[1,2] and Ulrich D. Jentschura[1] — [1]Max–Planck–Institut für Kernphysik, Heidelberg — [2]École Normale Supérieure, Paris

Even though the two–photon decay of hydrogen–like ions has been under intense investigations for more than a half century, the analysis of this process still raises a number of unresolved problems. The problems concern, for example, the two–photon transition from the excited into the ground state which passes the real intermediate state [1]. Such a transition leads to the narrow *resonances* in the energy spectrum of emitted photons. The proper treatment of these resonances is required for computing the total decay rates obtained after an integration over the energy of one of the emitted photons. In our contribution, therefore, we present a quantum electrodynamical approach based on on a careful mathematical handling of the resonances infinitesimally displaced from the photon integration contour [2]. By making use of this approach, we obtain the finite, physically sensible results for the decay rates of the two–photon $3s \to 1s$ and $4s \to 1s$ transitions in neutral hydrogen as well as in hydrogen–like xenon Xe^{53+} and uranium U^{91+} ions.

[1] J. D. Cresser *et al.*, Phys. Rev. A **33** (1986) 1677.
[2] U. D. Jentschura, J. Phys. A **40** (2007) F223.

A 25.9 Do 16:30 Poster C3

Soft X-ray spectroscopy on highly charged ions — •Thomas Baumann, Sascha Epp, Martin Simon, José R. Crespo López-Urrutia, and Joachim Ullrich — Max-Planck Institut für Kernphysik, Heidelberg, Germany

A flat-field grazing incidence grating spectrometer has been used to study the emission spectra of highly charged ions (HCI) in the soft X-ray region, covering a spectral range from 5 to 40 nm. HCIs were produced and confined at the FLASH-EBIT (Electron Beam Ion Trap), which is capable of preparing ions of essentially any element up to charge states with ionisation energies from 100 eV to 50 keV. In order to improve the spectral resolution beyond our current limits, a new soft X-ray spectrometer has been designed and assembled. It enhances the linear dispersion (and thus the resolution) by a factor of three. These two instruments are ideal not only for spectroscopic diagnostics requiring wide spectral coverage but also for precision wavelength measurements. As an example, measurements at excitation energies between 100 eV and 400 eV covering Xe and Fe in low charge states (XeIX to XeXV, FeVII to FeXV) are presented. The Xe data are particularly relevant for the next generation of semiconductor microlithography devices.

A 25.10 Do 16:30 Poster C3

Two-electron QED contributions to the ground state binding energy in He-like Kr ions — •Paul H. Mokler[1], José R. Crespo López-Urrutia[1], Fred J. Currell[2,3], Nobuyuki Nakamura[3], Shunsuke Ohtani[3], Hiro Tawara[1], Joachim Ullrich[1], and Hiroyuki Watanabe[3] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Queen's University, Belfast BT7 1NN, Northern Ireland, U.K. — [3]University of Electro-Communications, Chofu, Tokyo 182-0021, Japan

The two-electron QED contributions to the ground state binding energy of He-like Kr(34+) ions has been determined in two independent experiments performed with electron beam ion traps (EBIT) in Heidelberg (HD) and Tokyo (BT, Belfast-Tokyo collaboration). X-rays arising from radiative recombination (RR) of free electrons to the ground state of initially bare Kr(36+) and hydrogen-like Kr(35+) ions were observed as a function of the interacting electron energy. The K edge absorption by thin Eu and W foils provided fixed photon energy references used to measure the difference in binding energy, ΔE-2e, between the H- and He-like Kr ions (35+ and 34+, respectively). The two independent measurements agree well, yielding a final result of ΔE-2e = 641.8 (+/-1.7) eV. This value confirms recent theoretical results totally based on rigorous QED calculations. Its accuracy is just of the order required to access screened radiative QED contributions.

A 25.11 Do 16:30 Poster C3

Messung der Polarisation für den radiativen Elektroneneinfang in U^{91+} — •S. Hess, H. Bräuning, C. Brandau, S. Geyer, A. Kumar, R. Märtin, R. Reuschl, U. Spillmann, Th. Stöhlker, M. Trassinelli, S. Trotsenko und G. Weber — GSI, Darmstadt, Germany

Die lineare Polarisation der Röntgenstrahlung beim radiativen Elektroneneinfang (REC) in hochgeladene Schwerionen entzog sich bis vor kurzem experimentellen Studien [1]. Theoretische Untersuchungen zeigen jedoch eine starke Empfindlichkeit der Polarisation auf die Details des Prozesses, so z.B. auf die Spin-Polarisation der beteiligten Teilchen [2]. Wir präsentieren neue Messungen zur Polarisation für den Einfang in die K-Schale und erstmals auch für die j-Unterzustände der L-Schale von U^{91+} Ionen (Energie: 43 MeV/u). Zum Nachweis der Polarisation kam erstmals ein speziell für diesen Zweck entwickeltes Si(Li) Compton-Polarimeter mit einer Ortsauflösung von ca. 2 mm und einer aktiven Fläche von 64×64 mm^2 zum Einsatz. Durch die Kombination von Orts-, Zeit- und Energieauflösung und Multihit-Fähigkeit entspricht das Verhalten dieses Detektors dem eines idealen Compton-Polarimeters. Dies wird durch eine erste Auswertung der Polarisation für den K-REC, die charakteristische K_α-Strahlung sowie durch entsprechende Monte-Carlo Simulationen bestätigt.

[1] S. Tashenov et al., Phys. Rev. Lett. 97 (2006) 223202
[2] J. Eichler und Th. Stöhlker, Pys. Rep. 439 (2007) 1

A 25.12 Do 16:30 Poster C3

Spectroscopy of neutral Radium — •Aran Mol, Subhadeep De, Klaus Jungmann, Hans Wilschut, and Lorenz Willmann — KVI, University of Groningen, Groningen, The Netherlands

The heavy alkaline earth atoms radium is uniquely sensitive towards parity and time reversal symmetry violations due to a large enhancement of an intrinsic permanent electric dipole moment of the nucleous or the electron. Furthermore, radium is sensitive to atomic parity violation and the nuclear anapole moment. To prepare such experiments spectroscopy of relevant atomic states need to be done. At a later stage we will build a neutral atom trap for radium. We have built an atomic beam of the short lived isotope ^{225}Ra with a flux of several 10^4 atoms/sec. We are preparing the laser spectroscopy using this beam setup. In the preparation for efficient laser cooling and trapping we have successfully trapped barium, which is similar in it's requirements for laser cooling. The techniques which we have developed with barium can be used to trap rare radium isotopes. We report on the progress of the experiments.

A 25.13 Do 16:30 Poster C3

Neue Methoden zur Bestimmung der Lamb-Verschiebung in schweren H-artigen Ionen — •Regina Reuschl für die FOCAL-Kollaboration — GSI, Darmstadt, Deutschland — IKF, Universität Frankfurt, Deutschland

Um die Effekte der Quantenelektrodynamik (QED) auf die Grundzustandsbindungsenergie in schweren H-artigen Ionen, sehr genau bestimmen zu können [1], ist ein neuartiges hochpräzises Transmission-Kristallspektrometer, aufgebaut in einer FOcusing Compensated Asymmetric Laue (FOCAL) Geometrie [2], am Experimentierspeicherring (ESR) der GSI in Darmstadt getestet worden. In diesem Beitrag präsentieren wir die Ergebnisse dieses Experimentes. Ziel des Experimentes ist die hochpräzise Bestimmung der Ly-α-Übergänge in H-artigem Pb^{81+}, die durch Stöße mit einem Krypton Gastarget erzeugt werden. Aufgrund der sehr geringen Photoneneffizienz des Spektrometers, lediglich 10^{-8}, sind die Orts- und Energieauflösung eines segmentierten Germanium-Detektors eine notwendige Voraussetzung für eine erfolgreiche Durchführung des Experiments. Durch eine Kollaboration mit dem Forschungszentrum Jülich [3] haben wir ein Detektorsystem mit den gewünschten Eigenschaften erhalten. Die Kombination aus Detektor und Spektrometer erlaubt uns, alle Energien eines interessanten

Energiebereiches simultan zu messen.

[1] S. Fritzsche, P. Indelicato, and Th. Stöhlker, J. Phys. B: At. Mol. Opt. Phys. **38**, S707 (2005)

[2] H.F. Beyer et al., Spectrochimica Acta Part B **59**, 1535 (2004)

[3] D. Protić et al., IEEE Trans. Nucl. Sci. **52**, 3194 (2005)

A 25.14 Do 16:30 Poster C3

Bragg-Kristallspektrometrie der $K_{\alpha 1}$- und $K_{\alpha 2}$-Emissionslinien von Zink — •Renate Märtin[1,2], Martino Trassinelli[1,3,4], Heinrich F. Beyer[1], Ajay Kumar[1], Pierre Planchette[5] und Thomas Stöhlker[1,4] — [1]Gesellschaft für Schwerionenforschung, Darmstadt, Germany — [2]IKF, Universität Frankfurt, Germany — [3]Institut des Nanosciences de Paris, France — [4]Physikalisches Institut, Universität Heidelberg, Germany — [5]École Normale Supérieure de Cachan, Paris, France

Mit einem Bragg-Kristallspektrometer wurden die $K_{\alpha 1}$- und $K_{\alpha 2}$-Linien im Emissionspektrum von Zink mit einer Auflösung von ca. 1 eV bestimmt. $K_{\alpha 1}$- und $K_{\alpha 2}$-Emissionslinien verschiedener Elemente dienen in der Präzisionsspektroskopie als Kalibrierstandards. Eine solch hohe Auflösung erlaubt es, eine Linienanalyse auf dem Niveau einzelner beitragender Komponenten (Satellitenlinien, Linien des entsprechenden Ions nach Auger-Emissionen etc.) durchzuführen. Hochpräzise Daten liegen bereits für benachbarte Atome wie z.B. Kupfer vor [1]. Für Zink und den dazugehörigen Energiebereich von 8,6 keV gibt es bisher keine Messung mit äquivalenter Genauigkeit.

Mit Hilfe einer Röntgenröhre wurde ein Zinkblock bestrahlt ($E = 30$ keV), und das entstandene Fluoreszensspektrum mit einem zylindrisch gekrümmten Germaniumkristall (220) unter einem Winkel von 46° auf eine ortsempfindliche Röntgen-CCD-Kamera abgebildet. Die Daten für Zink werden mit den Referenzmessungen für Kupfer von Deutsch et al. [1] und eigenen Kupfermessungen verglichen.

[1] M. Deutsch *et al.*, Physical Review A **51**, 283 (1995).

A 25.15 Do 16:30 Poster C3

Röntgenspektroskopie an hochgeladenen Schwerionen an der GSI, Darmstadt — •Alexander Mayr[1,2], Bernd Sicherl[1,2], Joachim Jacoby[1,2], Thomas Kühl[2], Olga Rosmej[2], Daniel Zimmer[2], Bernhard Zielbauer[2], Paul Neumayer[2] und Rustam Berezov[1,2] — [1]Institut für Angewandte Physik, Uni Frankfurt — [2]GSI, Darmstadt

Im Rahmen des PHELIX Laser Projekts an der GSI, Darmstadt, wird zur Zeit 7,3 nm Röntgenlaser betrieben, der vom 1kJ-Verstärker des PHELIX-Lasers optisch gepumpt wird. Mit Hilfe des Röntgenlasers soll Spektroskopie an extrem hoch geladenen (Li-ähnlichen) Schwerionen durchgeführt werden. An der GSI stehen hoch geladene Schwerionen bis hin zu Uran zur Verfügung. Diese Kombination aus Schwerionenstrahl und Röntgenlaser erlaubt eine genaue spektroskopische Bestimmung der quantenmechanischen Zustände von Atomkernen. Für Li-ähnliche Ionen liefert die Theorie ausreichend genaue quantenelektrodynamische Modelle, deren Vorhersagen durch Vergleich mit den Ergebnissen des Experimentes überprüft werden können. Der Beitrag beschäftigt sich mit dem experimentellen Konzept und der geplanten Strahlzeit am Experimentierspeicherring ESR. Vorgestellt werden die Ergebnisse der Versuche mit dem 7,3 nm Samarium-Röntgenlaser und der aktuelle Stand der zugehörigen Detektorentwicklung.

A 25.16 Do 16:30 Poster C3

Program package for semi-empirical analysis of the fine- and hyperfine structure of complex atoms — •Jerzy Dembczyński, Jaroslaw Ruczkowski, and Magdalena Elantkowska for the Dembczynski-Collaboration — Chair of Quantum Engineering and Metrology, Poznan University of Technology, Nieszawska 13B, 60-965 Poznan, Poland

The experimental work combined with semi-empirical calculations is a very efficient tool for the investigations of the fine- and hyperfine structure of the complex atoms.

We present a set of programs for the analysis of the fine- and hyperfine structure. The input data for the calculations are : the fine structure energy levels, the g_J-factors and the hyperfine structure (hfs) A and B constants of experimentally observed levels.

The programs are used for the analysis of electron systems containing any number of configurations up to four open shells. In the energy matrix generated, all kinds of electrostatic, magnetic and correlated electrostatic and magnetic interaction, up to second order perturbation theory, were included.

As a result, we obtain predicted energy values for all the levels of the system considered, their exact spectroscopic description and also g_J-factors and hfs A and B constants.

This work was supported by Polish Ministry of Science and Higher Education under the project N519 033 32/4065

A 26: Posters: BECs, ultracold gases and plasmas

Zeit: Donnerstag 16:30–18:30 Raum: Poster C3

A 26.1 Do 16:30 Poster C3

Cold collisions of K atoms studied by precision spectroscopy — Stephan Falke[1,2], Matthias Riedmann[1], Jan Friebe[1], Horst Knöckel[1], Eberhard Tiemann[1], and •Christian Lisdat[1,3] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Department of Physics, Yale University, New Haven, U.S.A. — [3]Physikalisch-Technische Bundesanstalt Braunschweig

The interaction in ultracold thermal and quantum degenerate atomic clouds are dominated by binary collisions. Precisely these interactions make ultracold atoms the interesting field of research they are, since they determine BEC properties, produce Feshbach resonances, or allow forming molecules. All these points are closely related to the interaction potential of two colliding atoms. We report our laser-spectroscopic investigation of the least bound levels in the ground state X $^1\Sigma_g^+$ of $^{39}K_2$ undertaken on a molecular beam [1]. We measured in a two-laser lambda scheme energy differences of ground state levels in the order of 1 250 cm^{-1} with a precision better than 5 MHz applying a femtosecond frequency comb and iodine lines for frequency calibration. Precise models of the interaction potentials allow for an accurate description of cold collisions, e.g., Feshbach resonance positions. In a further step of the experiment we will test the precision of the mass-scaling to other isotope combinations based on the Born-Oppenheimer approximation using the isotopomere $^{39}K^{41}K$, which is sufficiently abundant for observation in a molecular beam based on a natural potassium [1].

[1] J. Chem. Phys. **125**, 224303 (2006), Phys. Rev. A **76**, 012724 (2006).

A 26.2 Do 16:30 Poster C3

EIT cooling beyond the Lamb Dicke limit — •Maryam Roghani and Hanspeter Helm — Department of Molecular and Optical Physics, Stefan-Meier-Straße 19, D-79104 Freiburg

Morigi et al have shown, that by applying two laser beams to a trapped atomic sample in a way that EIT(Electromagnetically Induced Transparency) condition is satisfied, there is the a possibility of cooling the sample to the ground state of the trap[1].This scheme proves highly efficient in case of cooling ions in tight traps when the condition of small Lamb-Dicke parameter and the condition of spontaneous emission rate smaller than trap frequency can be met.Transferring this scheme to typical cases of neutral atoms trapped in optical dipole trap environments neither of these conditions can be stringently met. In the neutral atom case typical values of the Lamb-Dicke parameter are in the range of 0.2-1 and spontaneous emission rate is much greater than trap frequency. We explore this situation by developing the Liouville equation for a density matrix describing states of the vibrational and electronic motion of the sample by taking into account the modification of the EIT line-shape due to vibrationally off-diagonal transitions in emission and absorption. [1].F.Schmidt-Kaler, J.Eschner, G.Morigi, C.F.Roos, D.Leibfried, A.Mundt, R.Blatt, Laser cooling with electromagnetically induced transparency:application to trapped samples of ions or neutral atoms, Appl.Phys.B 73,807(2001).

A 26.3 Do 16:30 Poster C3

Observations and Simulation of the evaporation process in an optical dipole trap — •Christoph Käfer[1], Thomas Boll[1], Riad Bourouis[1,2], Jürgen Eurisch[1], and Hanspeter Helm[1] — [1]Department of Molecular and Optical Physics, Stefan-Meier-Str. 19, 79104 Freiburg — [2]Institut für Angewandte Physik, Universität Bonn

We investigate the temporal development of atom number and atom temperature in an optical dipole trap which is established by a focused

CO_2 laser. At full power the trap frequencies in radial and longitudinal direction are $v_r = 2.4$ kHz and $v_z = 160$ Hz. When forcing the evaporation process by lowering the laser power, these trap frequencies and the elastic scattering rate decrease and spilling of atoms prior to rethermalization is playing an ever more important role as the evaporation process proceeds. Also the effect of gravity becomes a crucial factor at the end of the evaporation process. To our knowledge no published models account for all these parameters, and they cannot quantitatively explain the observations. We present a numerical model which can quantitatively account for all these parameters. In our model, the atoms are distributed according to a chopped Maxwell-Boltzmann distribution, where atoms with a kinetic energies above the potential depth are removed from the sample. After calculating the redistributed kinetic energy of two randomly chosen particles after scattering, the energy distribution of the entire sample can be updated and chopped again. In this fashion natural evaporation and forced evaporation can be traced out numerically. We compare predictions of this recursive model to our experimental result.

A 26.4 Do 16:30 Poster C3

An apparatus for ultracold Fermi gases using sodium and lithium — •Jens Appmeier, Marc Repp, Stefan Weis, Anton Piccardo-Selg, Jan Krieger, Elisabeth Brama, Peter Krüger, and Markus K. Oberthaler — Kirchhoff-Institut für Physik, Heidelberg

We report on the setup of an apparatus for cooling fermionic ^{6}Li atoms to quantum degeneracy. As a refrigerant for the fermions, ^{23}Na is used and standard cooling schemes are applied. By tuning the interatomic interactions of ^{6}Li via Feshbach resonances it is possible to study the BEC-BCS crossover. We intend to study this regime in lower dimensions by making use of optical lattices. The current progress of the experimental setup will be reported.

A 26.5 Do 16:30 Poster C3

Stochastic field equations for a finite Bose gas — •Sigmund Heller and Walter T. Strunz — Physikalisches Institut, Universität Freiburg

Based on the P-representation of the grand canonical and, more remarkably, the canonical density operator of a Bose field, we introduce corresponding stochastic field equations. Although strictly valid for non-interacting Bosons, we may include a mean-field interaction to describe the behaviour of weakly interacting Bose gases at finite temperature. The usual ("classical") thermal field state based on the Gross-Pitaevskii energy functional is obtained in the infinite-temperature limit. Nicely, our "quantum" field equations do not suffer from cut-off problems which is reflected by spatial correlations of the driving thermal noise. We present numerical simulations for various applications - mainly in the non-interacting regime.

A 26.6 Do 16:30 Poster C3

Dynamics of a Spinor-BEC in a radio-frequency-dressed magnetic trap — •Stephan Middelkamp[1], Igor Lesanovsky[2], and Peter Schmelcher[1,3] — [1]Theoretische Chemie, Physikalisch-Chemisches Institut, Universität Heidelberg, INF 229, 69120 Heidelberg, Germany — [2]Institut für Theoretische Physik, Universität Innsbruck, Technikerstraße 25, A-6020 Innsbruck, Austria — [3]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg, Germany

We theoretically investigate the dynamics of a quasi-one-dimensional $F = 1$ Spinor Bose-Einstein Condensates in a magnetic trap. Due to the coupling of the trap to the magnetic quantum number the $m_F = 1$ and $m_F = -1$ components experience inverse trapping potentials, whereas the $m_F = 0$ component experiences no trapping potential at all. We have chosen a double well as trapping potential for the $m_F = 1$ component. Consequently, the $m_F = -1$ component experiences a local potential minimum at the barrier of the double well potential and potential maxima at the position of the wells. In each well resides a BEC of atoms in the $m_F = 1$ state and at the barrier a BEC of atoms in the $m_F = -1$ state. With microwaves one can excite the atoms in the $m_F = -1$ state to the $m_F = 0$ state. Thus eliminating effects of the magnetic trap. Nevertheless, the $m = 0$ component remains trapped due to the interaction with the atoms in the $m_F = 1$ state. The strength of this interaction can be tuned by changing the number of atoms in the $m_F = 1$ state.

A 26.7 Do 16:30 Poster C3

Interaction of Ultra-Cold Atoms with Individual Carbon Nanotubes — •Gabriela Visanescu[1], Philipp Schneeweiss[1], Michael Gierling[1], Hannah Schefzyk[1], Andreas Günther[1], Germán Sinuco[2], Thomas Judd[2], Carsten Weiss[3], Reinhold Walser[3], and József Fortágh[1] — [1]Physikalisches Institut, Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen — [2]School of Physics and Astronomy, University of Nottingham, University Park, Nottingham, NG7 2RD — [3]Institut für Quantenphysik, Universität Ulm, D-89069 Ulm

We designed an atom chip to study the interaction of ultra-cold 87Rb atoms with an individual carbon nanotube (CNT). The chip is loaded from a magnetic trap via adiabatic transfer. Once on the chip, a 4-wire waveguide together with a conveyor belt facilitate moving the atoms to the CNT. Precise control over position and speed allow the study of atom scattering and quantum reflection from the tube.

As outlined in Ref. 1, the interaction will be dominated by the Casimir-Polder-potential between atoms and the CNT. Observing the atomic motion by absorption imaging as well as single atom detection techniques, we will be able to experimentally determine the Casimir-Polder-potential.

[1] R. Fermani, S. Scheel, and P.L. Knight, Phys. Rev. A 75, 062905 (2007)

A 26.8 Do 16:30 Poster C3

Bose-Einstein Condensates in Superconducting Microtraps — •Brian Kasch, Daniel Cano, Helge Hattermann, Reinhold Kleiner, Dieter Kölle, Claus Zimmermann, and József Fortágh — Physikalisches Institut, Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen

We present progress toward producing Bose-Einstein condensation in a superconducting magnetic microtrap. The scientific objective is the coupling of cold atoms to superconducting devices. An experimental system consisting of a BEC apparatus, and a Helium flow cryostat has been set up. A gas of Rb-87 atoms has been loaded into a magneto-optical trap. This cloud will be cooled by forced evaporation, and subsequently translated 5cm by means of optical tweezers to a magnetic microtrap generated on a niobium chip at 4,2 K.

We developed numerical methods for calculating magnetic fields in the vicinity of superconducting surfaces. Inhomogeneous current densities within the superconductor have been calculated using an energy-minimization procedure that relies on the London equations. Corresponding superconducting chips have been produced using optical lithography and lift-off techniques.

In a first experiment, we plan to measure the coherence time of a spin-polarized atomic cloud near a superconducting surface. Theoretical predictions show the spin-flip lifetime should be increased by several orders of magnitude as compared to the normal conducting state of the same wire. The current state of the experiment will be presented.

A 26.9 Do 16:30 Poster C3

An ion in a sea of ultracold atoms — •Stefan Schmid, Sascha Hoinka, Albert Frisch, and Johannes Hecker Denschlag — Universitaet Innsbruck, Technikerstrasse 25 / IV, 6020 Innsbruck

We report on the status of our new hybrid ion/atom trap experiment where a single trapped Ba^+ ion will be immersed into a Bose-Einstein condensate of ^{87}Rb atoms. First experiments will focus on the investigation of the interaction between the ion and the sea of ultracold neutral atoms. We plan to study elastic as well as inelastic scattering processes, e.g. charge transfer and molecule formation. We describe in detail our setup which will feature an optical transport of a Rb BEC into a linear Paul trap, where the Barium ion is stored.

A 26.10 Do 16:30 Poster C3

Multi-channel scattering in cylindrical confining trap — •Shahpoor Saeidian[1], Vladimir Melezhik[2], and Peter Schmelcher[1] — [1]Universität Heidelberg, Heidelberg, Germany — [2]JINR,Dubna,Russian Federation

We suggest a grid method for multi-channel scattering of two particles under a transverse harmonic confinement. With this approach we analyze the transverse excitations of two colliding particles under the action of the confining trap. We consider collisions of two identical as well as distinguishable particles in the harmonic traps with single frequency permitting the center-of-mass (c.m.) separation in both the cases. In the zero-energy limit in single-mode regime we reproduce the known confinement-induced resonances (CIRs) for bosonic, fermionic and mixed collisions. The collisions under the tranverse harmonic confinement then analyzed in the multi-mode regime up to four

open transverse channels. Possible applications can include, e.g., atom-atom collisions in atom wave guides and impurity scattering in quantum wires.

A 26.11 Do 16:30 Poster C3

An ultracold Bose gas in an optical dipole trap — •Lena Simon and Walter Strunz — Physikalisches Institut, Hermann-Herder-Str. 3, Universität Freiburg, 79104 Freiburg

Motivated by an experiment in the Helm group at the university of Freiburg, we study an ultracold Bose gas in an optical dipole trap consisting of one single laser beam. An analytical expression for the density of states for the trap potential beyond the usual harmonic approximation is obtained. We are thus able to determine the critical temperature for Bose-Einstein condensation and find that it depends on a cutoff parameter. We discuss these surprising subtleties in some detail. Moreover, we study the dynamics of evaporative cooling and observe a significant deviation from the well-established harmonic approximation.

A 26.12 Do 16:30 Poster C3

A novel atom chip based experiment for studies of Bose-Fermi mixtures in one dimension — •Philipp Wicke and Nicolaas Johannes van Druten — Van der Waals-Zeeman Institute, University of Amsterdam, The Netherlands

One-dimensional (1D) quantum gases offer exciting opportunities to explore many-body physics. A distinguishing feature of quantum physics in 1D is that exactly solvable models are available. Currently we investigate Bose gases in the 1D regime [1]. We plan to extend these studies to Bose-Fermi and Fermi-Fermi mixtures in 1D, and to make use of the many advantages that atom chips offer in this regard: rapid sympathetic cooling of the fermion ^{40}K by the boson ^{87}Rb on an atom chip has already been demonstrated [2], atom chips enable the study of individual realizations of 1D quantum gases [1], and finally they allow the use of versatile radio-frequency dressed potentials [3] that can be both state- and species-selective [4]. The latter should enable tuning the interaction parameters, in order to realize the above-mentioned exactly solvable models in our experiments. Our current design of an apparatus to investigate quantum degenerate mixtures of Rb and K will be presented at the conference. It includes a double chamber vacuum setup and a two-species MOT powered by a system of amplified diode lasers.

[1] van Amerongen et al., arXiv:0709.1899v1 (2007)
[2] Aubin et al., Nature Phys. **2**, 384 (2006)
[3] Hofferberth et al., Nature Phys. **2**, 710-716 (2006)
[4] Extavour et al., in *Atomic Physics 20*, 241-249 (2006)

A 26.13 Do 16:30 Poster C3

Ultracold bosonic and fermionic atoms in optical lattices — •Lucia Hackermueller, Thorsten Best, Ulrich Schneider, Sebastian Will, Dries van Oosten, and Immanuel Bloch — Johannes-Gutenberg-Universitaet Mainz, Staudingerweg 7, 55099 Mainz, Deutschland

The manipulation of ultracold fermionic and bosonic quantum gases in optical lattices permits access to a wide field of exciting experiments ranging from the investigation and simulation of solid state physics to quantum computing and ultracold chemistry.

In our apparatus we sympathetically cool ^{40}K and ^{87}Rb atoms. We use one of our lattice beams as a blue plug in a magnetic quadrupole trap. After precooling to 2μK we transfer our atoms to a crossed optical dipole trap and cool both species to quantum degeneracy. Subsequently we load pure potassium samples or potassium / rubidium mixtures into a blue detuned three dimensional optical lattice. The combination of a red detuned dipole trap with a blue detuned optical lattice enables us to vary the external confinement while leaving the lattice potential unchanged.

This setup allows for the investigation of various interesting experiments like heteronuclear molecules, molecular potassium in optical lattices, in situ cloud sizes of spin polarized potassium or spin mixtures. We report on the latest results from the experiment.

A 26.14 Do 16:30 Poster C3

Magnetic Trapping of metastable Magnesium — •M. Riedmann, J. Friebe, K. Moldenhauer, A. Pape, A. Voskrebenzev, E. M. Rasel, and W. Ertmer — Institute of Quantum Optics, Leibniz University Hannover

Magnesium is one of the few atoms suitable for an neutral atom optical lattice clock. The magic wavelength is predicted between 430 and 470 nm and Mg offers interesting features like a reduced sensitivity to room temperature blackbody radiation, which may limit the accuracy of Sr lattice clocks in the near future. Currently, the high temperatures of more than 3 mK in a MOT based on the strong singlet cooling transition at 285 nm would prevent high loading efficiency into an optical lattice. Therefore, our goal is to produce and cool metastable magnesium, where much lower temperatures are achievable ($T_{recoil} = 5\ \mu K$). In this contribution, we present the production of metastable Magnesium by two-color excitation in the singlet system and further decay to the metastable states $^3P_2$ and $^3P_1$. The metastable atoms are captured in a magnetic trap and detected on the triplet cooling transition at 383 nm. We are able to load more than 10^6 atoms in the long-living $^3P_2$ state into the trap at temperatures below 1 mK. We expect to get much higher atom numbers and lower temperatures in a MOT based on the triplet cooling transition.

A 26.15 Do 16:30 Poster C3

Towards a mesoscopic ensemble of ultracold fermions — •Matthias Kohnen[1], Friedhelm Serwane[1], Timo Ottenstein[1], Thomas Lompe[1], and Selim Jochim[1,2] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Ruprecht-Karls-Universität, Heidelberg

Ensembles consisting of a small number of ultracold fermionic atoms can serve as a model for other finite systems such as electrons in atoms or nuclei in a nucleus. So far experiments studying large fermionic systems have been very succesful in controlling the interparticle interaction by an external magnetic field using a so-called Feshbach resonance. This allows to turn a degenerate Fermi gas reversibly into a molecular Bose-Einstein condensate. The way to a mesoscopic system would be to prepare an almost pure molecular BEC, convert it into a deeply degenerate Fermi gas and lower the depth of the trapping potential reducing the number of available quantum states which leads to a controlled spilling of atoms from the trap.

On this poster we present our progress in setting up a new apparatus for the preparation of such a mesoscopic system with defined atom number in an optical microtrap. So far, we have realized a magneto-optical trap collecting up to 10^9 ^{6}Li atoms in one second. The next step will be the transfer of the atoms into an optical dipole trap where condensation will be achieved by forced evaporative cooling. This molecular Bose-Einstein condensate will provide excellent starting conditions for our future experiments.

A 26.16 Do 16:30 Poster C3

Dynamics of a low-dimension ultracold Bose gas — •Cédric Bodet and Thomas Gasenzer — Institüt für Theoretishe Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg

The dynamical evolution of a Bose-Einstein condensate trapped in a one-dimensional lattice potential is investigated theoretically in the framework of the Bose-Hubbard model. The emphasis is set on the far-from-equilibrium evolution in a case where the gas is strongly interacting. This is realized by an appropriate choice of the parameters in the Hamiltonian, and by starting with an initial state, where one lattice well contains a Bose-Einstein condensate while all other wells are empty. Oscillations of the condensate as well as non-condensate fractions of the gas between the different sites of the lattice are found to be damped as a consequence of the collisional interactions between the atoms. We approach this problem by numerically solving the Schrödinger equation for this model. We study in detail the particle number fluctuations on-site and between sites in order to investigate the conditions for producing squeezed states in experimentally realistic configurations.

A 26.17 Do 16:30 Poster C3

A frozen Rydberg gas as a model system for quantum critical phenomena — •Peter Kollmann[1], Björn Butscher[1], Hendrik Weimer[2], Ulrich Raitzsch[1], Rolf Heidemann[1], Vera Bendkowsky[1], Robert Löw[1], Hans Peter Büchler[2], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, D-70550 Stuttgart — [2]Institut für Theoretische Physik III, Universität Stuttgart, Pfaffenwaldring 57, D-70550 Stuttgart

We present our recent experimental results on Rydberg excitation of magnetically trapped Rubidium atoms.

In a thermal cloud of a few μK we observe coherent, collective and strongly blocked excitation induced by the van der Waals interaction among the Rydberg atoms [1]. The observed scaling behaviour can be well understood in the framework of critical phenomenona. The reversibility of the excitation dynamics was measured with an echo type

technique [2]. With this experiments we prove the coherence of the excitation and gain insight into the dephasing due to interactions. We further observed a signature of the phase transition to a Bose-Einstein condensate in the fraction of excited Rydberg atoms when cooling the thermal cloud below T_c. The main features of the experimental data are reproduced by a simulation using a superatom model [3].

[1] R. Heidemann et al., Phys. Rev. Lett. 99, 163601 (2007)
[2] U. Raitzsch et al., arXive: quant-phys 0706.2639 (2007)
[3] R. Heidemann et al., arXive: cond-mat 0710.5622 (2007)

A 26.18 Do 16:30 Poster C3

Trapped Rydberg Ions — •Markus Mueller[1], Linmei Liang[1,2], Igor Lesanovsky[1], and Peter Zoller[1] — [1]Institute for Theoretical Physics, University of Innsbruck, and Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, Innsbruck, Austria — [2]Department of Physics, National University of Defense Technology, Changsha 410073, China

We study Rydberg states of ions which are trapped in a linear Paul trap. In such trap the ions are confined by an electric quadrupole field and a ponderomotive force due to an oscillating quadrupole. Using a two-body approach in order to model the Rydberg ions we derive the Hamiltonian for Rydberg excitations in a linear ion crystal. We discuss the creation of strong state-dependent dipole-dipole interaction among the ions using microwave dressing of Rydberg states. This system offers the possibility to study Rydberg excitation dynamics of a mesoscopic ensemble in a well-structured environment and allows the implementation of strongly interacting spin models.

A 26.19 Do 16:30 Poster C3

Ultracold plasma from the gases of light atoms — •Andrey Lyubonko, Amar S. Sil, and JM Rost — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Ultracold neutral plasmas are formed by photoionizing laser cooled atoms near the ionization threshold [1,2]. The electron temperature is from 1-1000K and the ion temperature is around 1K. The fundamental interest in these systems originates in the possibility of creating strongly coupled plasma. We are mainly interested in the theoretical description of dynamics of ultracold metastable Li+ (1s2s 3S) plasma. The special feature of this system is that the ions are in metastable state and can release its internal energy (ΔE = 59eV per ion) due to inelastic collisions. This energy can drastically change the dynamics of the plasma. The important inelastic collisions are superelastic collisions, three-body recombination which leads to Rydberg atoms formation, subsequent excitation, deexcitation and ionization of Rydberg atoms. We tackle this problem by molecular dynamics (MD) technique including inelastic collisions by rates. We will identify the parameter regimes in which such a metastable ultracold plasma can exist.

1.T. C. Killian, Science 316, 705 (2007)
2.T.C. Killian, T. Pattard, T. Pohl, J.M. Rost, Phys.Rep. 449(2007), 77-130

A 26.20 Do 16:30 Poster C3

Excitation of Rydberg atoms in a Bose Einstein Condensate — •Cenap Ates and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden

In an ultracold but non-degenerate gas the dynamics of interacting Rydberg atoms is strongly influenced by the properties (density, spatial structure) of the ground state environment. The macroscopic phase coherence present in a quantum degenerate gas like a BEC, allows for the opposite scenario, i.e. an effect of the Rydberg excitations on the dynamics of the ground state system, due to an additional phase imprinted by the Rydberg impurites onto the condensate wavefunction.

We study the excitation dynamics of the Rydberg atoms and the subsequent time evolution of the BEC by setting up a hierarchy of density matrix equations for the coupled BEC-Rydberg system and treating them self-consistently up to the level of pair correlations of the Rydberg atoms.

A 26.21 Do 16:30 Poster C3

The Subharmonics of Electron Emission from Ultracold Plasmas: Collective Plasma Oscillations vs. Individual Excitation of Rydberg Atoms — •Yurii V. Dumin and Jan M. Rost — MPI for the Physics of Complex Systems, Dresden

One of the most interesting phenomena revealed recently in the study of ultracold plasma clusters is a series of distinctive peaks in the electron emission from an ultracold plasma subjected to external radio waves [R.S. Fletcher, et al., PRL 96, 105003 (2006)]. An evident interpretation of this effect is the excitation of resonant plasma oscillations. This explanation, however, encounters difficulties in the quantitative description of the higher harmonics. The alternative point of view, which will be discussed in our report, is a resonant perturbation of highly excited Rydberg atoms in the plasma, resulting in the escape of the respective Rydberg electrons from the system. The main advantage of this mechanism is an easy generation of the higher harmonics and their robustness with respect to the geometry and size of the cluster.

A 27: Posters: Electron scattering and recombination

Zeit: Donnerstag 16:30–18:30 Raum: Poster C3

A 27.1 Do 16:30 Poster C3

Characteristic x–ray emission following the radiative capture and projectile excitation in relativistic ion–atom collisions — •Stephan Fritzsche[1,2], Andrey Surzhykov[1,3], and Thomas Stöhlker[2,4] — [1]Max–Planck–Institut für Kernphysik, Heidelberg — [2]Gesellschaft für Schwerionenforschung (GSI), Darmstadt — [3]École Normale Supérieure, Paris — [4]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg

During the last decade, the radiative electron capture of target electrons by high–Z ions and the projectile excitation have been studied in great detail at the GSI storage ring in Darmstadt. Typically, both of these processes lead to an alignment of the excited states of the ions with regard to the incident beam direction and, hence, to an anisotropic emission and polarization of the decay x–ray photons [1]. From the angular and polarization analysis of this emission, however, one can learn a lot about the structural properties as well as the dynamical behaviour of few–electron heavy ions in very strong electromagnetic fields.

In this contributions, we shall consider especially the Lyman–α_1 ($2p_{3/2} \rightarrow 1s_{1/2}$) and K$\alpha_1$ ($1s2p_{3/2} \rightarrow 1s^2_{1/2}$) radiative transitions in hydrogen– and helium–like uranium ions and compared the emitted characteristic radiation for an initial electron capture *versus* the Coulomb excitation of the projectiles [2].

[1] S. Fritzsche *et al.*, J. Phys. B **38** (2005) S707.
[2] A. Surzhykov *et al.*, Phys. Rev. A **74** (2006) 052710.

A 27.2 Do 16:30 Poster C3

The high efficiency spin-resolved electron detection in a mini-Mott analyzer — •Rustam Berezov and Joachim Jacoby — Institut für Angewandte Physik, Max von Laue-Str. 1, D-60438 Frankfurt / Main

The investigation of spin-dependent measurements with electron polarimeters gives a lot of additional information concerning many physical processes. The main problem in polarized electron studies at keV-particle energy is now not longer the source intensity, but rather the low efficiency of usual electron polarimeters, like Mott scattering polarimeter. We present here the design and performance of a compact mini-Mott spin analyzer of electron polarization. Due to the compact small size the cylindrical-electrode Mott polarimeter has a higher efficiency which is defined as ratio I/Io of intensity for scattered electrons divided by the initial current. In turn the increasing efficiency improves the figure of merit.

A 27.3 Do 16:30 Poster C3

Dielektronische Rekombination wasserstoffähnlicher Uranionen — •Dietrich Bernhardt[1], Carsten Brandau[2], Zoltan Harman[3], Christophor Kozhuharov[2], Alfred Müller[1], Werner Scheid[4], Stefan Schippers[1], Eike W. Schmidt[1], Deyang Yu[5], Karl Beckert[2], Anton N. Artemyev[8], Peter Beller[2], Sebastian Böhm[1], Fritz Bosch[2], Fred Currell[6], Bernhard Franzke[2], Alexandre Gumberidze[2], Jörg Jacobi[1], Paul Mokler[1,3], Fritz Nolden[2], Uwe Spillmann[2], Zbigniew Stachura[7], Markus Steck[2], Thomas Stöhlker[2] und Ilya I. Tupitsyn[8] — [1]Institut für Atom- und

Molekülphysik, JLU Gießen — [2]GSI, Darmstadt — [3]MPI für Kernphysik, Heidelberg — [4]Institut für Theoretische Physik, JLU Gießen — [5]Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou, P. R. China — [6]Physics Department, Queens University, Belfast, UK — [7]Instytut Fizyki Jądrowej, Kraków, Poland — [8]Department of Physics, St. Petersburg State University, Russia

Im Rahmen eines am GSI Experimentierspeicherring mit überlagerten Ionen- und Elektronenstrahlen durchgeführten Experiments wurden erstmals absolute Ratenkoeffizienten der dielektronischen Rekombination DR von U^{91+} gemessen. Diese Untersuchung der e-e-Wechselwirkung in den stärksten möglichen atomaren Feldern erfolgte bei Kollisionsenergien von 63 bis 90 keV. Individuelle Gruppen von KLL-Resonanzen konnten aufgelöst werden. Die Ergebnisse werden mit QED-Effekte berücksichtigenden Atomstrukturrechnungen verglichen. Der starke Einfluss der Breitwechselwirkung auf den DR-Prozess wird belegt.

A 27.4 Do 16:30 Poster C3

Photoionization of excited states in kinematically complete experiments — •Thomas Pflueger, Xueguang Ren, Arne Senftleben, Alexander Dorn, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Reaction microscopes (RM) deliver kinematically complete information on atomic and molecular ionization processes. We want to extend this method to the investigation of excitation, e.g. by charged particle impact. By means of a laser pulse the excited states are photoionized and the released electron and the ion are detected. From the energies and angular distributions of these particles we gain detailed information on the primary collision process. Examples for electron impact excitation of atoms will be presented.

A 27.5 Do 16:30 Poster C3

Systematic effects on the absolute energy determination of dielectronic recombination resonances — •Christian Beilmann, José R. Crespo López-Urrutia, Volkhard Mäckel, Hiro Tawara, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

The dielectronic recombination (DR) is a resonant electron capture process by a highly charged ion, where the kinetic energy of the captured electron is transfered to a bound electron thus exciting it. By measuring DR, the electronic energy levels can be determined with high precision. The ions are produced and trapped in an electron beam ion trap (EBIT) using an intense electron beam. Varying the electron energy allows measuring the electron capture resonances. In these experiments the space charge potential of the electron beam (partially compensated by the ions) has to be inferred. In previous experiments it was observed that the trapping potential depth had an influence on the space charge potential as well as on its linearity with respect to the current of the electron beam. The precise determination of the space charge potential is an issue of ongoing experiments. The resonance energies of the DR at several trapping potentials are studied and compared with each other. Applying the corrections obtained in these investigations leads to an higher accuracy for the absolute resonance energies.

A 27.6 Do 16:30 Poster C3

A Photoemission Electron Source Based on GaAs Semiconductor Crystal Used in a Reaction Microscope — •Vladimir Borovik, Steffen Lüdemann, Toshiyasu Ichioka, Claus Dieter Schröter, Alexander Dorn, and Joachim Ullrich — Max-Planck Institute of Nuclear Physics, Saupfercheckweg 1, D-69117 Heidelberg, Germany

The dynamics of fundamental few-body quantum systems can be investigated by observing single and multiple ionization of atoms and molecules in the near-threshold region. We employ recoil-ion and electron momentum spectroscopy which allows us to measure the momentum vectors of several ions and electrons created in such reactions. For electron-impact ionization, the momentum resolution critically depends on the incident electron beam quality. For our experiments an electron source with a narrow energy distribution at small energies of the beam is required. Recent measurements were limited by the characteristics of the thermocathode electron source used (see, e.g., [1]). We have built a new pulsed photoemission electron source based on a GaAs semiconductor crystal activated to a state of negative electron affinity. Since the electron beam is produced by irradiating the crystal surface with a picosecond laser beam, its time structure is essentially defined by the characteristics of the laser. The current status of the photoelectron source and main technical issues related to its implementation in the collision experiments using the so-called reaction microscope [2] will be discussed. [1] M. Durr et al., Phys. Rev. Lett. 96, 243202 (2006). [2] J. Ullrich et al., Rep. Prog. Phys. 66, 1463 (2003).

A 27.7 Do 16:30 Poster C3

Spin-resolved electron scattering on lead (Pb) and bismuth (Bi) atoms — •Volker Hamelbeck, Philipp Brüner, and G. Friedrich Hanne — Physikalisches Institut, 48149 Münster, Germany

The physics of interactions between low-energetic spin-polarised electron beams and atomic as well as molecular targets have comprehensively been studied in our group. An interesting aspect of this field are collision experiments on heavy metal atoms such as Pb and Bi where spin-orbit and exchange effects occur simultaneously. This is still a difficult task for theory.
For a description of these processes, the scattering parameters S_P, S_A, $\vec{T}$ and $\vec{U}$ are introduced. Through the polarisation function S_A the spin-dependence of the DCS is quantified. The other parameters are determined by measurement of $\vec{P}$ and $\vec{P}'$, the electron polarisation before and after scattering respectively.
In such an experiment, the spin-polarised electron beam is guided from a GaAs source to the collision centre where it hits the heavy metal vapour emanating from an oven. A rotatable spectrometer is used to collect the scattered electrons whose spin polarisation is subsequently determined in a Mott-detector.
At the conference, details of the apparatus and current results will be presented. Through further investigations, we will gain a deeper insight into the physics of collisions between spin-polarised electrons and atoms.

A 27.8 Do 16:30 Poster C3

Isotopieverschiebung in der dielektronischen Rekombination von Li-artigen $^{A}Nd^{57+}$ Ionen — •C. Brandau[1], C. Kozhuharov[1], Z. Harman[2], A. Müller[3], S. Schippers[3], Y.S. Kozhedub[4], D. Bernhardt[3], S. Böhm[3], J. Jacobi[3], E.W. Schmidt[3], P.M. Mokler[2,3], F. Bosch[1], H.-J. Kluge[1], Th. Stöhlker[1], K. Beckert[1], P. Beller[1], F. Nolden[1], M. Steck[1], A. Gumberidze[1], R. Reuschl[1], U. Spillmann[1], F.J. Currell[5], I.I. Tupitsyn[4], V.M. Shabaev[4], U.D. Jentschura[2], C.H. Keitel[2], A. Wolf[2] und Z. Stachura[6] — [1]Gesellschaft für Schwerionenforschung, 64291 Darmstadt, Germany — [2]Max-Planck Institut für Kernphysik, 69117 Heidelberg, Germany — [3]Justus-Liebig-Universität, 35392 Gießen, Germany — [4]St. Petersburg State University, 198504 St. Petersburg, Russia — [5]Queen's University, Belfast BT7 1NN, UK — [6]Instytut Fizyki Jądrowej, 31-342 Kraków, Poland

Die Messung von Isotopieverschiebungen (IS) im Resonanzspektrum der dielektronischen Rekombination ist eine neuartige, hochpräzise und sensitive Methode, um Parameter von Kernladungsverteilungen experimentell zu bestimmen. Dies gilt insbesondere für schwere Wenig-Eletronensysteme, wie das in dieser Arbeit untersuchte Li-artige $^{A}Nd^{57+}$. Ergebnisse eines ersten Experiments am Speicherring ESR der GSI mit den beiden stabilen Nd-Isotopen A=142 und A=150 werden vorgestellt und diskutiert. Die Ableitung der Radiusänderung $^{142,150}\delta\langle r^2\rangle$ aus der IS erfolgte im Rahmen eines voll relativistischen Ansatzes unter Berücksichtigung von QED Korrekturen.

A 27.9 Do 16:30 Poster C3

The Coulomb four-body problem: double ionization of helium by electron impact close to threshold — •Xueguang Ren, Alexander Dorn, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Heidelberg

The dynamics of many-particle quantum systems is still one of the most important unsolved problems in quantum physics. For three-electron escape from an ionic potential close to the fragmentation threshold theories predict a symmetric electron emission with 120° relative angles [1] as well as a T-shape emission with two electrons emitted back-to-back and the third one emitted perpendicular [2]. We have realized such a strongly correlated three electron continuum in electron impact double ionization of helium atoms. Kinematical complete experiments were performed for impact energies 27 eV and 5 eV above the break-up threshold. For the higher energy (27 eV) symmetric as well as T-shape configurations are observed [3]. For 5 eV excess energy only symmetric electron emission is found strongly supporting the Wannier-like saddle point dynamics on which Klar and Schlecht base their work [1].
[1] H. Klar and W. Schlecht, J. Phys. B 9, 1699 (1976)
[2] A. Emmanouilidou and J. M. Rost, J. Phys. B 39, 4037 (2006)

[3] M. Dürr et al., Phys. Rev. Lett. 98, 193201 (2007).

A 27.10 Do 16:30 Poster C3

Nuclear lifetime prolongation in resonant electron recombination processes — •Adriana Pálffy[1], Zoltan Harman[1], Christophor Kozhuharov[2], Carsten Brandau[2], Christoph H. Keitel[1], Werner Scheid[3], and Thomas Stöhlker[2] — [1]MPI für Kernphysik, Heidelberg — [2]Gesellschaft für Schwerionenforschung, Darmstadt — [3]Institut für Theoretische Physik, Giessen

Processes at the borderline between atomic and nuclear physics open the possibility to explore properties of exotic nuclei via experiments involving highly-charged ions. The coupling of nuclei to atomic shells in the process of nuclear excitation by electron capture (NEEC) can lead to a number of nuclear effects.

In the resonant process of NEEC, the recombination of a continuum electron into a bound atomic shell leads to the excitation of the nucleus [1]. When occuring into an excited electronic bound state, NEEC is followed by fast x-ray emission, changing the electronic configuration of the ion. For some heavy highly-charged ions, the electronic decay suppresses the internal conversion decay channel and leads therefore to lifetime prolongation of the excited nuclear state and an increase of the NEEC resonance strengths of up to two orders of magnitude. Applications of these effects to the measurement of the not yet experimentally observed NEEC and their possible relevance to dense astrophysical plasmas are discussed.

[1] A. Pálffy, W. Scheid, Z. Harman, Phys. Rev. A 73, 012715 (2006)

A 27.11 Do 16:30 Poster C3

Low energy electron cooler for the Heidelberg CSR — •andrey shornikov, dmitry orlov, manfred grieser, and andreas wolf — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

The Cryogenic Storage Ring (CSR) is currently under development at MPI-K in Heidelberg. The CSR is an electrostatic ring intended for storing ions in the 20-300 keV energy range (E/Q) in cryogenic environment at temperature down to 2K. CSR will be equipped with an electron cooler which has to combine cooler and electron target functions. For cooling operation at given ion energies corresponding electron energies are in the range from 160 down to a few eV. Main problems in such operation mode are the decrease of electron beam intensity, the degradation of the electron longitudinal energy spread[1] and the distortion of stored low energy ion trajectories during beams merging. For the CSR a new merging beam section layout[2] together with a photocathode based cold electron source[3] (tested at the Heidelberg TSR) have been proposed. In this paper we present the design of CSR electron cooler including the cryogenic implementation together with numerical calculations of the electron beam longitudinal and transverse energy spread in merged beam section.

[1] D. Orlov et al. Proc COOL05 (2005) pp 478-487
[2] H. Fadil et al. Proc EPAC2006 pp 1630-1632
[3] D. Orlov et al , J. Phys.:Conf.Ser., 4,pp 290-295(2005)

A 27.12 Do 16:30 Poster C3

Dielectronic recombination of highly charged ions for optimization of charge breeding — •Lodewijk Arntzen, José R. Crespo López-Urrutia, Volkhard Mäckel, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, 69256 Heidelberg, Germany

The dielectronic recombination (DR) resonances for highly charged ions have been investigated through measurements of ions extracted from the Heidelberg electron beam ion trap (EBIT) while slowly scanning the electron energy. At strong DR resonances, the yield of the He-like krypton ions was substantially reduced, whereas that of the Li-like krypton ions was correspondingly increased. At slightly higher electron energies similar features were observed for the Li- and Be-like krypton ions. The DR process can be therefore used to modify significantly the ion charge state distribution, and by judicious choice of the excitation and recombination energies and timing, to concentrate the extracted ion current into particularly interesting charge states while depleting the undesired ones. This is particularly important for future charge breading experiments with short-lived radioactive isotopes, in order to improve the total charge breeding efficiency and to reduce the radioactive ion beam losses in the accelerator system. The convenient control of this parameters in an EBIT makes them well suited for this purpose.

A 28: Transport in ultracold gases and plasmas (jointly with Q)

Zeit: Freitag 11:00–12:30 Raum: 3C

Hauptvortrag A 28.1 Fr 11:00 3C

Nonlinear coherent transport of waves in disordered media — •Thomas Wellens[1] and Benoît Grémaud[2] — [1]Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3a, 79104 Freiburg — [2]Laboratoire Kastler Brossel, Université Pierre et Marie Curie, 4 place Jussieu, 75252 Paris Cedex 05

In general, transport of waves in disordered media cannot fully be described as a simple diffusion process, since wave interference effects lead to a reduction or even complete suppression of the diffusion constant (weak or strong localization) and the appearance of a coherent backscattering peak.

In this talk, I present a diagrammatic theory for treating the impact of nonlinearities on such disorder-induced localization phenomena [1]. The theory is applied to describe propagation of weakly interacting Bose-Einstein condensates in disordered potentials, on the one hand, and multiple scattering of light in nonlinear media, on the other one. In particular, the conditions under which nonlinear effects diminish or enhance the height of the coherent backscattering peak, and the consequences for the occurrence of Anderson localization of light and cold matter are discussed. Finally, I also talk about the possibility to incorporate quantum-mechanical many-body effects (for example multi-photon scattering processes from strongly driven two-level atoms), which generally lead to decoherence, thereby reducing the localization effects.

[1] T. Wellens and B. Grémaud, PRL (in press)

A 28.2 Fr 11:30 3C

One-Dimensional Rydberg Gas in a Magnetoelectric Trap — •Bernd Hezel[1], Michael Mayle[2], Igor Lesanovsky[3], and Peter Schmelcher[1,2] — [1]Physikalisches Institut, Universität Heidelberg, 69120 Heidelberg, Germany — [2]Theoretische Chemie, Universität Heidelberg, 69120 Heidelberg, Germany — [3]Institut für Theoretische Physik, Universität Innsbruck, 6020 Innsbruck, Austria

We study the quantum properties of Rydberg atoms in a magnetic Ioffe-Pritchard trap superimposed by a homogeneous electric field. Trapped Rydberg atoms in long-lived electronic states can be created with *permanent* electric dipole moments of several hundred Debye. The resulting dipole-dipole interaction in conjunction with the radial confinement gives rise to an effectively one-dimensional ultracold Rydberg gas with a macroscopic interparticle distance. Analytical expressions for the electric dipole moment and the required linear density of Rydberg atoms can be derived.

A 28.3 Fr 11:45 3C

Structural phase transitions in low-dimensional ion crystals — •Gabriele De Chiara[1], Shmuel Fishman[2], Tommaso Calarco[3], and Giovanna Morigi[1] — [1]Departament de Fisica, Universitat Autonoma de Barcelona, 08193 Bellaterra, Spain — [2]Physics Department, Technion, 32000 Haifa, Israel — [3]Institut für Quanteninformationsverarbeitung, Universität Ulm, D89069 Ulm, Germany

A chain of singly-charged particles, confined by a harmonic potential, exhibits a sudden transition to a zigzag configuration when the radial potential reaches a critical value, depending on the particle number. This structural change is a phase transition of second order, whose order parameter is the crystal displacement from the chain axis. We study analytically the transition using Landau theory and find full agreement with numerical predictions by J. Schiffer [Phys. Rev. Lett. 70, 818 (1993)] and Piacente et al. [Phys. Rev. B 69, 045324 (2004)]. Our theory allows us to determine analytically the system's behaviour at the transition point.

A 28.4 Fr 12:00 3C

Damped Bloch Oscillations of Bose Einstein Condensates in disordered gradient fields — •Sascha Drenkelforth, Georg

Kleine Büning, Johannes Will, Wolfgang Ertmer, and Jan Arlt — Institut für Quantenoptik, Universität Hannover, Welfengarten 1, 30167 Hannover

Optical lattices are excellent tools to probe the nature of quantum degenerate Bose gases and serve as an ideal testing ground for theories originating in solid state physics.

One of the most peculiar effects in the framework of periodic potentials is the well known Bloch Oscillation (BO) of quantum particles. Under the influence of a constant force they undergo an oscillatory motion instead of a linear acceleration.

We report on our investigations of damped BO in optical lattices. The addition of disorder to the prior perfect optical lattice leads to an dephasing and therefore to a damping of the BO [1]. The experimental results show increased damping with stronger disorder and a strong broadening of the quasimomentum distribution during the time evolution of the BO.

These results promise a better understanding of the role of disorder in quantum transport experiments.

[1] Schulte et al., cond-mat/0707.3131(2007)

A 28.5 Fr 12:15 3C

Sympathetic Cooling of Ions using Laser-Cooled One-Component Plasmas — •Michael Bussmann[1], Ulrich Schramm[2], Peter Thirolf[1], Veli Kolhinen[1], Jerzy Szerypo[1], Juergen Neumayr[1], Michael Sewtz[1], and Dietrich Habs[1] — [1]Ludwig-Maximilians-Universitaet Muenchen, Am Coulombwall 1, 85748 Garching — [2]Forschungszentrum Dresden-Rossendorf, Bautzner Landstraße 128, 01328 Dresden

We present new simulation results on sympathetic cooling of ions for precision experiments. Using a laser-cooled one-component plasma of 10^5 $^{24}Mg^+$ ions it is possible to stop and sympathetically cool ions to mK temperatures. With the proposed cooling scheme fast and efficient cooling of rare nuclei for precision in-trap physics, e.g. subsequent mass measurements in Penning traps, becomes possible. In the talk we will give an overview of previous results before presenting new results on the stopping dynamics, especially the interplay of collective dynamics, plasma stability and recooling efficiency.

[1]Bussmann M. et al., European Physical Journal D 45(1) (2007) 129-132.

[2]Bussmann M. et al., Hyperfine Interactions 173(1-3) (2007) 27-34.

A 29: Electron scattering and recombination

Zeit: Freitag 11:00–12:45 Raum: 3D

Hauptvortrag A 29.1 Fr 11:00 3D

Bridging atomic and nuclear physics in nuclear excitation by electron capture — •Adriana Pálffy, Jörg Evers, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Heidelberg

In the resonant process of nuclear excitation by electron capture (NEEC), the recombination of a continuum electron into a bound atomic shell leads to the excitation of the nucleus [1].

NEEC can act as an efficient nuclear excitation mechanism, in particular as triggering mechanism releasing on demand the energy stored in nuclear isomers - long-lived nuclear excited states [2]. The isomeric state can be excited via NEEC to a higher level which is associated with freely radiating states and therefore releases the energy of the metastable state. We present total cross sections for NEEC isomer triggering considering experimentally confirmed low-lying triggering levels and reaction rates based on realistic experimental parameters in ion storage rings. A comparison with other isomer triggering mechanisms shows that, among these, NEEC is the most efficient one [3].

An experimental verification of our findings at the borderline of atomic and nuclear physics may be provided by upcoming ion storage ring facilities and ion beam traps which will commence operation in the near future.

[1] A. Pálffy, W. Scheid, Z. Harman, Phys. Rev. A 73, 012715 (2006)
[2] P. M. Walker and G. D. Dracoulis, Nature 399, 35 (1999)
[3] A. Pálffy, J. Evers, C. H. Keitel, Phys. Rev. Lett. 99, 172502 (2007)

A 29.2 Fr 11:30 3D

Hochaufgelöste Elektronenspektroskopie an ionischen Targets — •Kristof Holste[1], Alfred Müller[1], Stefan Schippers[1] und Sandor Ricz[2] — [1]Institut für Atom- und Molekülphysik, Justus-Liebig-Universität Gießen — [2]Institute of Nuclear Research of the Hungarian Academy of Sciences, Debrecen, Hungary

Die Untersuchung von Elektron-Ion-Stößen ist auf Grund der um Größenordnungen kleineren Teilchendichten von ionischen Targets verglichen mit Gas- oder Festkörpertargets eine experimentelle Herausforderung. Totale Elektron-Ion-Wechselwirkungsquerschnitte werden heutzutage routinemäßig mit crossed- oder merged-beams-Anlagen gemessen. Dabei werden üblicherweise nur die umgeladenen Ionen als Reaktionsprodukte detektiert, nicht jedoch die emittierten Elektronen, die prinzipiell weitergehende Informationen über den Wechselwirkungsprozess liefern. Hier stellen wir eine crossed-beams-Anlage vor, in die ein zweistufiges Elektronenspektrometer integriert wurde. Das Spektrometer besteht aus einem sphärischen (1. Stufe) und einem zylindrischen (2. Stufe) Spiegelfeldanalysator mit azimutaler Symmetrie. In der ersten Stufe werden alle Elektronen, die vom Kreuzungspunkt des Ionen- und des Elektronenstrahls in die azimutale Streuebene emittiert werden, aufgesammelt und in die zweite Stufe transportiert. Dort wird sowohl die Energie als auch die Winkelverteilung der emittierten Elektronen mit einem positionsempfindlichen Mikrochannelplate-Detektor bestimmt. Erste Ergebnisse für die elastische Streuung an Cs^+-Ionen liegen vor.

A 29.3 Fr 11:45 3D

Exploring correlated high-field few-electron QED by means of dielectronic recombination in $W^{69+...72+}$ ions — •Volkhard Mäckel, José Ramón Crespo López-Urrutia, Antonio Javier González Martínez, Zoltan Harman, Hiro Tawara, and Joachim Ullrich — MPI für Kernpysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

The photorecombination of highly charged few-electron tungsten ions W^{69+} to W^{72+} has been investigated at the Heidelberg electron beam ion trap. By scanning the electron beam energy between 39 keV and 44 keV over the KLL dielectronic recombination region and monitoring the emitted x rays, the dielectronic resonance energies of the different charge states could be determined relative to the heliumlike resonances with an relative error as low as 3 eV at 40 keV. At this level of experimental accuracy quantum electrodynamic (QED) and finite nuclear size contributions can be probed. A comparison with different predictions shows strong discrepancies for certain Li- and Be-like ion states while general agreement with other charge states is found. This confirms earlier findings for mercury (Hg^{75+} to Hg^{78+}) DR measurements [1,2].

[1] A. J. González Martínez et al., Phys.Rev. A 73 (2006) 052710
[2] Z. Harman et al., Phys Rev. A 73 (2006) 052711

A 29.4 Fr 12:00 3D

Electron-impact ionization of xenon ions — •Alexander Borovik Jr[1], Mohammad Gharabeih[2], Carsten Brandau[1], Stefan Schippers[1], and Alfred Müller[1] — [1]Institut für Atom- und Moleküöphysik, Justus-Liebig Universität, Giessen, Germany — [2]Jordan University of Science and Technology, Irbid, Jordan

With their many subshells at comparatively low binding energies xenon ions offer rich opportunities to study many-electron processes such as excitation followed by autoionization and resonant electron capture with subsequent multiple electron emission. In high-temperature plasmas Xe ions emit strongly in the extreme ultraviolet spectral range. Recent interest in applying the EUV radiation of xenon or tin ions to lithography has led to the construction of light sources based on laser-produced plasmas or gas discharges. In the effort to optimize for maximum radiation output a detailed understanding of the origin of the radiation and the production of the radiating ions is necessary.

We report on measurements of cross sections for electron-impact single ionization of Xe^{q+} ions with q ranging from 1 to 15. Xe ions are produced in charge states up to 27 by using an 10-GHz-electron cy-

clotron resonance (ECR) ion source. The electron-ion crossed beams technique is used for the measurement of cross sections for single and multiple ionization. Beside the measurement of absolute cross sections an energy-scanning method is applied to uncover detailed structures in the ionization cross sections.

A 29.5 Fr 12:15 3D

Nuclear properties and strong-field electron dynamics explored by dielectronic recombination — •Z. Harman[1], U.D. Jentschura[1], C.H. Keitel[1], W. Scheid[2], C. Brandau[3], C. Kozhuharov[3], T. Stöhlker[3], D. Bernhard[2], S. Schippers[2], A. Müller[2], V. Mäckel[1], H. Tawara[1], J.R. Crespo López-Urrutia[1], and J. Ullrich[1] — [1]Max-Planck-Institut für Kernphysik — [2]Justus-Liebig-Universität Giessen — [3]GSI Darmstadt

Dynamical and structural properties of heavy highly charged ions have been investigated by means of dielectronic recombination. Isotope shift measurements of low-lying resonances, combined with our atomic structure calculations, allow one to extract information on the nuclear charge distribution of the isotopes involved. We analyze the dependence of electron interaction and QED contributions on the nuclear size and calculate mass shift terms to determine the change of nuclear radii corresponding to the isotope shift in Li-like Nd measured with the ESR storage ring of the GSI Darmstadt [1,2]. This approach constitutes a new technique to determine nuclear radii. Furthermore, we study relativistic electron interaction and QED effects in the strong binding fields of heavy nuclei in collaboration with experiments with the HD-EBIT [3] and the ESR [2]. Our investigation confirm the role of relativistic corrections to the electron interaction in a dynamical process. [1] C. Brandau, C. Kozhuharov, Z. Harman, *et al.*, submitted (2007) [2] C. Brandau, C. Kozhuharov, A. Müller, *et al.*, J. Phys.: Conf. Ser. 58, 81-86 (2007) [3] V. Mäckel, A.N. Artemyev, J.R. López Crespo-Urrutia, *et al.*, We102, XXV ICPEAC, Book of Abstracts (2007)

A 29.6 Fr 12:30 3D

Anomalous quasi-elastic electron scattering from single H2, D2 and HD molecules at large momentum transfer - Indications of nuclear spin effects — •C. Aris Chatzidimitriou-Dreismann[1], Glyn Cooper[2], and Adam P. Hitchcock[2] — [1]Intitute of Chemistry, Technical University of Berlin, D-10623 Berlin Germany — [2]Brockhouse Institute for Materials Research, McMaster University, Hamilton, ON, Canada L8S 4M1

Quasi-elastic electron scattering from gaseous H_2, D_2, a 50:50 mixture of H_2 and D_2 and HD is investigated with 2.25 keV impact energy and 100^o scattering angle, corresponding to a momentum transfer $\hbar q$ of 19.7 a.u. The energy transfer is less than the H-H, H-D or D-D bond dissociation energy. The spectral positions of the H and D recoil peaks are adequately explained by Rutherford scattering theory. Surprisingly, in the spectrum of the 50:50 H_2-D_2 mixture, the integrated intensity of the H peak is 31±4% lower (as compared to that of D) than predicted by Rutherford scattering, despite equal screening of nuclear charges by the electrons in all molecules. In contrast, the ratio of scattering intensities from HD agrees with the predictions of Rutherford scattering. Comparison is made with previous neutron Compton scattering (NCS) experiments from the equimolar H_2-D_2 mixture and HD, at much higher energy transfer in the range which can cause H-H bond breaking. The NCS results showed the same deviation (about 30%) from theory in both the H_2-D_2 mixture and HD. Connection to existing theories (on scattering dynamics of entangled particles) is made.

A 30: Precision spectroscopy III

Zeit: Freitag 14:00–15:15 Raum: 3C

A 30.1 Fr 14:00 3C

Laser Spectroscopy on Trapped Highly-Charged Ions using Soft X-rays from FLASH — •Sascha Epp[1], José Crespo López-Urrutia[1], Günter Brenner[1], Volkhard Mäckel[1], Paul Mokler[1], Joachim Ullrich[1], Rolf Treusch[2], Marion Kuhlmann[2], Mikhail Yurkov[2], Josef Feldhaus[2], Jochen Schneider[2], Michael Wellhöfer[3], Michael Martins[3], and Wilfried Wurth[3] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]DESY, Hamburg — [3]Institut für Experimentalphysik Universität Hamburg

Resonance laser spectroscopy, the most sensitive tool for atomic structure studies, has been severely limited due to the lack of appropriate light sources beyond the UV and especially the VUV region. With FLASH, the free electron laser in Hamburg, the soft x-ray region is now accessible for laser spectroscopy. Therefore transitions in heavy, few-electron systems — i.e. highly charged ions (HCI) — become open to this precision method. Here we report the measurement of the ground state transition between the $1s^2 2s\ 2S_{1/2}$ and $1s^2 2p\ 2P_{1/2}$ levels for Li-like Fe^{23+} ions by matching soft x-rays from FLASH together with HCI provided in a transportable EBIT. The present statistical accuracy is already superior to the theoretical uncertainties of the most accurate two-loop QED calculations.

A 30.2 Fr 14:15 3C

Frequency Measurements on the 2S-3S Transition of Lithium-7 and Lithium-6 — •Sánchez A. Rodolfo M.[1], Noerterhaeuser Wilfried[1,2], Andjelkovic Zoran[2], Ewald Guido[1], Geppert Christopher[1], Kluge Juergen[1], Kraemer Joerg[2], Nothhelfer Matthias[2], Tiedemann Dirk[2], Winters Danyal[3], and Zakova Monika[2] — [1]GSI mbH, Planckstr. 1, 64291 Darmstadt — [2]Institut für Kernchemie, Universität Mainz, Fritz-Straßmann-Weg 2, 55128 Mainz — [3]Institut für Kernphysik, Universität Münster, Wilhelm-Klemm-Straße 9, 48149 Münster

We report on the absolute frequency measurement of the 2S - 3S two-photon transition of lithium-7 and -6 by employing a frequency comb. The values we obtained in this measurement are a factor ten times better than the last reported ones. We also discuss how a detailed description of the line profile is necessary in order improve the measured values.

A 30.3 Fr 14:30 3C

Absolute frequency measurements on Mg^+ cooling transitions — •Valentin Batteiger[1], Maximilian Herrmann[1], Sebastian Knünz[1], Birgitta Bernhardt[1], Feng Zhu[2], Hans Schüssler[2], Thomas Udem[1], and Theodor W. Hänsch[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching — [2]Texas A&M University, College Station, Texas 77843

We present isotopically resolved absolute frequency measurements of both fine structure components of the 3s-3p transition in single, trapped magnesium ions. The transitions are observed in the limit of unresolved sidebands, which would lead to strongly asymmetric line shapes due to cooling and heating if only one laser were swept over the resonance. A novel spectroscopy scheme based on sympathetic cooling and spatially resolved detection allows to observe symmetric lines. The measurements contribute to astronomical searches for drifts of the fine structure constant in quasar absorption spectra and improve the accuracy over previous measurements by two orders of magnitude.

A 30.4 Fr 14:45 3C

Chemical Shift of K transitions in Manganese — Detlev Gotta, Thomas Strauch, and •Christian Weidemann — IKP, FZ Jülich

Precision measurements of X-ray energies in the few keV range must take into account chemical shifts of the Kα fluorescence radiation. In a recent measurement MnO_2 was used as calibration standard, which itself had to be calibrated against the precisely measured values of metallic Mn. For that, a systematic study of the shift in manganese compounds was performed by using a high precision Bragg-spectrometer. The energies of the K$\alpha_{1,2}$ transitions from Mn metal and Mn compounds were measured with a relative accuracy of 10 - 20 meV. According to the line shape model of [1] the Mn metal spectrum was fitted and the tabulated peak energy has been used for absolute calibration for the Kα_1 lines. The transition energies of the various Mn compounds, representing different valences of manganese, show significant chemical effects. Compared to previous measurements [2] the accuracy could be improved by factors 6 to 10. To check the spectrometer system for consistency the Kβ-spectra were measured for the same compounds. In agreement with previously obtained data, chemical shifts up to 1.6 eV were found for the K$\beta_{1,3}$ transition.

[1] Förster, E. et al., *Phys. Rev.* A 56 No. 6 (1997).
[2] Meisel, A.; Döring, E., *Über den Einfluss chemischer Bindung auf das Kα-Dublett von Mangan, Leipzig (1962).*

A 30.5 Fr 15:00 3C

Mg^+ - He^+ Mixed Crystals for High Precision Spectroscopy in the XUV — Sebastian Knünz[1], •Maximilian Hermann[1], Valentin Batteiger[1], Akira Ozawa[1], Feng Zhu[2], Thomas Udem[1], Hans Schüssler[2], and Theodor W. Hänsch[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, 85748 Garching — [2]Department of Physics, Texas A&M University, College Station, Texas 77843, USA

The 1s-2s two photon transition of singly ionized hydrogen-like helium at 60 nm is an interesting candidate for precision tests of bound state QED. Rapid progress in the development of high-power XUV frequency combs lets high resolution spectroscopy of this transition come in sight for the first time. We report on important steps towards this goal. In our novel 6-rod RF trap, we generated and analyzed cold mixed crystals.

A 31: Interaction with intense laser pulses III: VUV and X-ray light

Zeit: Freitag 14:00–15:45 Raum: 3D

A 31.1 Fr 14:00 3D

Ion Recombination and Delayed Expansion Dynamics of Rare Gas Clusters exposed to Intense XUV Laser Pulses — •Matthias Hoener[1], Heiko Thomas[1], Christoph Bostedt[1], Ekaterina Eremina[1], Lasse Landt[1], Hubertus Wabnitz[2], Rolf Treusch[2], Rubens de Castro[3], and Thomas Möller[1] — [1]IOAP, TU Berlin, Germany — [2]Hasylab at DESY, Hamburg, Germany — [3]LNLS, Campinas, Brazil

We have studied the ionisation processes of core – shell cluster systems exposed to intense XUV laser pulses up to 10^{14} W/cm^2 from the FLASH free electron laser. A strong size dependence of ionisation processes is observed for XeAr clusters. Charged fragments from the Xe core are almost absent in the mass spectra of large XeAr clusters ($< N >= 4000$). At the same time Ar ions up to 4+ are present. We propose that only the Ar surface layers disintegrate by coulomb explosion while atoms in the cluster core recombine and the expansion is delayed. The delayed expansion may have significant implications for future imaging experiments in the XUV and x-ray regime, since it can relax the restriction of x-ray pulse length given by the time when radiation damage sets in. The findings are compared to recent theoretical predictions.

A 31.2 Fr 14:15 3D

Streuexperimente an Clustern mit hochintensiver Strahlung des FLASH - FEL — •Daniela Rupp[1], Marcus Adolph[1], Ekatarina Eremina[1], Heiko Thomas[1], Matthias Hoener[1], Hubertus Wabnitz[2], Rolf Treusch[2], Christoph Bostedt[1] und Thomas Möller[1] — [1]IOAP - Technische Universität Berlin — [2]Hasylab at DESY

Streuexperimente sind eine erprobte Methode zur Bestimmung der Struktur von Materie. Durch die hochintensiven und ultrakurzen Laserpulse von Freie-Elektronen-Lasern kann nun erstmalig die Struktur von Nano-Objekten mittels Einzelschuss-Experimenten bestimmt werden. Hierbei wird die Auflösungsgrenze durch die Wellenlänge des Lasers von derzeit 13,7 nm am FLASH und zukünftig wenigen Angstrom am XFEL bestimmt.

In ersten Experimenten wurden die Pulse des FLASH an Xenonclustern mit Durchmessern im Bereich der Wellenlänge (13 bis 35 nm) gestreut. Die entstandenen Streubilder wurden mit auf der Mietheorie basierenden Simulationen verglichen und die Clustergrößen bestimmt. Anpassungen der optischen Konstanten in der Theorie an die gemessenen Streubilder lassen Rückschlüsse auf die Elektronendynamik des Clusters im Laserfeld zu. Die bisherigen Ergebnisse sind vielversprechend im Hinblick auf geplante Pump-Probe-Experimente in denen die dritte Harmonische des FEL als Probe-Puls die Dynamik der Coulombexplosion auflösen und die zeitliche Entwicklung von Clustergröße und Brechzahl bestimmen soll.

A 31.3 Fr 14:30 3D

Impulsspektroskopie an kleinen Clustern — •Sebastian Schorb, Matthias Hoener, Rainer Unterumsberger, Heiko Thomas, Thomas Möller und Christoph Bostedt — IOAP - Technische Universität Berlin

Spektroskopie mit COLTRIMS (cold target recoil ion momentum spectroscopy) Detektoren erlaubt detaillierte Untersuchungen der Fragmentation von Molekülen und Clustern, bei der die vektoriellen Impulse aller entstehenden ionischen Fragmente und Elektronen im vollen Raumwinkel gemessen werden. Wir untersuchen die Fragmentation von van-der-Waals Clustern und molekularen Diamanten nach Anregung mit weicher Röntgenstrahlung. Edelgascluster zeigen je nach Verhältnis von Coulomb- zu Oberflächenenergie ein charakteristisches Fragmentationsmuster, was im Rahmen des klassischen Tröpfchenmodells als Fission bzw. Explosion des Clusters interpretiert werden kann. Für die Untersuchung von Diamantclustern wurde eine Überschallexpansionsquelle konzipiert, die es ermöglicht, einen kalten Strahl von Diamantoiden für spektroskopische Untersuchungen zu erzeugen. Diese kovalenten Clustersysteme zeigen für resonante Anregungen ein charakteristisches Fragmentationsmuster. Das Fragmentationsverhalten beider Systeme wird verglichen und diskutiert.
Wir danken den Arbeitsgruppen von H. Schmidt-Böcking und R. Dörner der Universität Frankfurt (Main) für deren Unterstützung.

A 31.4 Fr 14:45 3D

Angular Resolved Photoemission from C_{60} in Intense Laser Fields — •Slawomir Skruszewicz, Nguyen Xuan Truong, Johannes Passig, Thomas Fennel, Andreas Przystawik, Josef Tiggesbäumker, and Karl-Heinz Meiwes-Broer — Institut of Physics, University of Rostock

Angular resolved photoelectron spectroscopy is a key method to gain deeper insight into the strong-field photoionization of complex systems, such as multi-electron atoms, molecules, and clusters. A powerful and direct technique for the simultaneous measurement of the energy and angular distribution of the photoelectrons is offered by Velocity Map Imaging spectrometry [1]. In order to resolve electrons with up to 1 keV kinetic energy we have developed a modified five-electrode setup. As a system benchmark we have analyzed the emission spectra from Xe atoms for fs laser excitation and find clear signatures from above-threshold, tunnel-, as well as atomic double ionization - in agreement with earlier studies [2,3]. As the first application of the system we have studied the angular resolved photoemission from C_{60} as a function of laser pulse length and laser intensity. We found signatures for above-threshold ionization and evidence for contributions of intermediate Rydberg levels [4,5].

[1] H. Helm et al., Phys. Rev. Lett. **70**, 3221 (1993).
[2] R.R. Freeman et al., Phys. Rev. Lett. **59**, 1092 (1987).
[3] V. Schyja et al., Phys. Rev. A **57**, 3692 (1998).
[4] E.E.B. Cambpell et al., Phys. Rev. Lett. **84**, 2128 (2000).
[5] M. Boyle et al., Eur. Phys. J. D **36**, 339 (2005).

A 31.5 Fr 15:00 3D

Two-Color Photoionization using High Intensity Extreme-UV Free Electron Laser (FLASH) and Near-IR Laser Pulses — •S. Duesterer[1], P. Radcliffe[1], W. B. Li[1], A. Azima[1], J. Dardis[2], P. Hough[2], K.D. Kavanagh[2], J. T. Costello[2], D. Glijer[3], D. Cubaynes[3], and M. Meyer[3] — [1]Hamburger Synchrotronstrahlungslabor HASYLAB at Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, D-22607 Hamburg, Germany — [2]National Center for Plasma Science and Technology, Dublin City University, Dublin, Ireland and School of Physical Sciences, Dublin City University, Dublin 9, — [3]LIXAM/CNRS, UMR 8624 Centre Universitaire Paris-Sud, Bâtiment 350, F-91405 Orsay Cedex, France

Two-photon two-color ionization of rare gases has been measured using an experimental system designed for single-shot photoelectron spectroscopy on free atoms and molecules at the Free Electron Laser in Hamburg (FLASH at DESY). Characteristic sidebands appear in the photoelectron spectra when the optical (Ti:Saph laser: 100 fs, 800 nm) and the FEL pulses overlap spatially and temporally. The cross-correlation curve points to a 250 fs rms jitter between the two sources at the experiment. Our experimental results agree well with theoret-

ical models of the two-color-ATI process and provide more detailed insights into atomic photoionization dynamics.

A 31.6 Fr 15:15 3D

Nonresonant inelastic x-ray scattering as a tool to study soft x-ray absorption edges using hard x rays: giant dipole resonances in barium and iodine compounds — •Christian Sternemann[1], Henning Sternemann[1], John S. Tse[2], and Metin Tolan[1] — [1]Fakultät Physik / DELTA, Technische Universität Dortmund, Dortmund, Germany — [2]Department of Physics & Engeneering Physics, University of Saskatchewan, Saskatoon, Canada

Giant dipole resonances are collective excitations which can be found in systems ranging from atoms, clusters to solids. These phenomena are usually studied by soft x-ray absorption, photoelectron and electron energy loss spectroscopy. With the advent of third generation synchrotron radiation sources, nonresonant inelastic x-ray scattering of core shell excitations became a prominent tool to study truly bulk sensitive shallow absorption edges with high energy photons. This technique is not only restricted to dipole transitions but can access final states of different symmetry employing its momentum transfer dependence. Especially, low energy excitations can be studied under high pressure. Giant resonances were measured in barite, several complex barium-silicon compounds and iodine-silicon clathrate. For the barium compounds the shape of the giant resonance is modulated depending on the environment the resonating barium atoms are embedded in. The onset of the resonance could be measured within a high pressure environment for the structure I barium intercalated silicon clathrate. Moreover, for iodine-silicon clathrate it was observed that the resonance is strongly suppressed for high momentum transfers.

A 31.7 Fr 15:30 3D

Autocorrelation Experiments with Soft X-ray FEL Pulses — R. Mitzner[2], W. Eberhardt[1], M. Neeb[1], T. Noll[1], M. Richter[3], S. Roling[2], M. Rutkowski[2], B. Siemer[2], A. Sorokin[3], K. Tiedtke[4], and •H. Zacharias[2] — [1]BESSY GmbH, Albert-Einstein-Str. 15,12489 Berlin, Germany — [2]Physikalisches Institut, Universität Münster, D-48149 Münster, Germany — [3]PTB, Abbe_Str. 2-12,D-10587 Berlin, Germany — [4]DESY, Nottkestr.85, 22603 Hamburg, Germany

We report first direct measurements of the average coherence time and temporal pulse length of soft X-ray fs pulses from the free-electron laser at DESY (FLASH) by means of linear and nonlinear autocorrelation.