Atomic Physics Division
Fachverband Atomphysik (A)

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Overview of Invited Talks and Sessions

(lecture rooms BAR 205, BAR 106, HSZ 01, HSZ 02, SCH A118, and SCH 251; Poster P1 and P2)

Invited Talks

A 1.1	Mon	10:30–11:00	BAR 205	**First results from multi-coincidence experiments at LCLS** — •Daniel Rolles, Benedikt Rudek, Artem Rudenko, Benjamin Erk, Lutz Foucar, Sascha Epp, Ilme Schlichting, Lothar Strüder, Joachim Ullrich, the CAMP collaboration
A 1.2	Mon	11:00–11:30	BAR 205	**X-FEL induced multi-photon processes** — •Bertold Krässig
A 1.3	Mon	11:30–12:00	BAR 205	**X-ray femtochemistry: Mapping the electronic structure of molecules during chemical reactions with x-ray spectroscopy** — •Philippe Wernet
A 5.1	Mon	14:00–14:30	BAR 106	**New insights in molecular photoionization physics - Coherence properties of the valence photoionization of N_2 and O_2** — •Jens Viefhaus, Markus Ilchen, Sascha Deinert, Leif Glaser, Frank Scholz, Peter Walter, Markus Braune, André Meissner, Lokesh Tribedi, Uwe Becker
A 5.2	Mon	14:30–15:00	BAR 106	**Appearance of coherent localization due to the Auger Doppler effect** — •Burkhard Langer, Rainer Hentges, Oliver Kugeler, Markus Braune, Sanja Korica, Jens Viefhaus, Daniel Rolles, Uwe Hergenhahn, Hironobu Fukuzawa, Xiaojing Liu, Yusuke Tamenori, Masamitsu Hoshino, Hiroshi Tanaka, Christophe Nicolas, Catalin Miron, Omar Al-Dossary, Kiyoshi Ueda, Uwe Becker
A 8.1	Mon	16:30–17:00	BAR 106	**Ultrafast Electron and Nuclear Dynamics in Dissociative Ionization of H2/D2 probed by Molecular Frame Photoemission.** — •Danielle Dowek
A 8.2	Mon	17:00–17:30	BAR 106	**High-resolution soft X-ray spectroscopies of isolated species** — Victor Kimberg, Andreas Lindblad, Xiao-Jing Liu, Christophe Nicolas, Emmanuel Robert, Johan Södreström, Oksana Travnikova, •Catalin Miron
A 8.3	Mon	17:30–18:00	BAR 106	**Double Photoionization of Aromatic Hydrocarbons** — •Ralf Wehlitz
A 9.1	Tue	10:30–11:00	BAR 205	**Ultraintense X-Ray Induced Multiple Ionization and Double Core-Hole Production in Molecules** — •Nora Berrah, Mats Larsson, Raymond Feifel, Kiyoshi Ueda, Kevin Prince
A 9.2	Tue	11:00–11:30	BAR 205	**Experiments at SPring-8 FEL: from EUV to X rays** — •Kiyoshi Ueda
A 9.3	Tue	11:30–12:00	BAR 205	**Coupling dependence regarding the Cooper minima positions in two-photon ionization of rare gases** — •Markus Braune, Toralf Lischke, Ande Meissner, Markus Ilchen, Sascha Deinert, Jens Viefhaus, Andre Knie, Uwe Becker
A 12.1	Tue	14:00–14:30	BAR 106	**Dissociative charge transfer into molecular ions** — •Lothar Ph. H. Schmidt, Reinhard Dörner, Horst Schmidt-Böcking
A 14.1	Fri	10:30–11:00	BAR 106	**Synchrotron radiation spectroscopy of ions** — •Alfred Müller
A 14.2	Fri	11:00–11:30	BAR 106	**Doppler effect in fragment autoionization following core-to-valence excitation in molecular oxygen.** — •Marc Simon, Renaud Guillemin, Eiji Shigemasa

A 15.1	Wed	10:30–11:00	BAR 106	**Ultracold chemistry and dipolar collisions in a quantum gas of polar molecules** — •Silke Ospelkaus, Amodsen Chotia, Marcio de Miranda, Brian Neyenhuis, Kang-Kuen Ni, Dajun Wang, Jun Ye, Deborah Jin
A 19.1	Thu	10:30–11:00	BAR 205	**Cluster ionization in strong laser fields - NIR vs. XUV** — •Thomas Fennel, Jörg Köhn, Christian Peltz, Mathias Arbeiter
A 22.1	Thu	14:00–14:30	BAR 106	**Influence of two-center electronic correlations on atomic processes** — •Carsten Müller, Alexander B. Voitkiv, Bennaceur Najjari, Jose R. Crespo Lopez-Urrutia, Zoltan Harman
A 25.1	Thu	16:30–17:00	BAR 106	**Conical intersections in an ultracold gas** — •Sebastian Wüster, Alexander Eisfeld, Jan-Michael Rost
A 27.1	Fri	10:30–11:00	BAR 205	**Plasmon Driven Higher Harmonics Generation** — In-Yong Park, Seungchul Kim, Joon-Hee Choi, •Seung-Woo Kim
A 27.2	Fri	11:00–11:30	BAR 205	**Structure and Dynamics of Free Nanoparticles: From Charging to Time-Resolved Photoemission** — •Eckart Rühl
A 27.3	Fri	11:30–12:00	BAR 205	**Terahertz Nano Plasmonics** — •Dai-Sik Kim
A 27.4	Fri	12:00–12:30	BAR 205	**Coulomb complexes: Electron emission from clusters in strong FEL pulses** — •Ulf Saalmann
A 27.5	Fri	12:30–13:00	BAR 205	**Appearance of Surface and Volume Plasmons in Fullerenes** — •Sanja Korica, Axel Reinköster, Markus Braune, Jens Viefhaus, Daniel Rolles, G. Fronzoni, D. Toffoli, M. Stener, P. Decleva, O. Al-Dossary, Burkhard Langer, Uwe Becker
A 28.1	Wed	10:30–11:00	BAR 205	**Quantum Interference Control of Free and Bound Electrons in Atoms and Molecules** — •Thomas Pfeifer

Invited Talks of the Joint Symposium The Concept of Reality in Physics (SYRP)

See SYRP for the full program of the symposium.

SYRP 1.1	Wed	14:30–15:00	HSZ 01	**What is realism in physics? What is the price for maintaining it?** — •Anthony J. Leggett
SYRP 1.2	Wed	15:00–15:30	HSZ 01	**Testing concepts of reality with entangled photons in the laboratory and outside** — •Anton Zeilinger
SYRP 1.3	Wed	15:30–16:00	HSZ 01	**Special relativity and quantum entanglement: How compatible are they?** — •Tim Maudlin
SYRP 2.1	Wed	16:30–17:00	HSZ 01	**What can we learn from Bell's inequalities violations: the answers of Einstein and Feynman** — •Alain Aspect
SYRP 2.2	Wed	17:00–17:30	HSZ 01	**Physics and Narrative** — •David Albert
SYRP 2.3	Wed	17:30–18:00	HSZ 01	**The relativity of inertia and reality of nothing** — •Alexander Afriat
SYRP 2.4	Wed	18:00–18:30	HSZ 01	**Obtaining Information about and Controlling Quantum Particles: Quantum Engineering** — •Dieter Meschede

Invited Talks of the Joint Symposium Cultural Heritage in the Light of Physical Methods (SYCH)

See SYCH for the full program of the symposium.

SYCH 1.1	Thu	14:00–14:30	HSZ 02	**Radiocarbon dating of cultural objects: Limit** — •Hans-Arno Synal
SYCH 1.2	Thu	14:30–15:00	HSZ 02	**From Lascaux to Rembrandt. Insights into invisible traces of paintings and drawings from physical methods** — •Ina Reiche
SYCH 1.3	Thu	15:00–15:30	HSZ 02	**IPANEMA, A European research platform for the study of ancient and historical materials** — •Loïc Bertrand
SYCH 1.4	Thu	15:30–16:00	HSZ 02	**3D X-ray view of treasures** — •Birgit Kanngiesser, Ioanna Mantouvalou, Wolfgang Malzer
SYCH 2.1	Thu	16:30–17:00	HSZ 02	**Looking below the surface of paintings by help of neutrons** — •Claudia Laurenze-Landsberg, Carl Otto Fischer
SYCH 2.2	Thu	17:00–17:30	HSZ 02	**X-ray fluorescence analysis using synchrotron radiation excitation** — •Martin Radtke, Günter Buzanich, Uwe Reinholz, Heinrich Riesemeier
SYCH 2.3	Thu	17:30–18:00	HSZ 02	**Metabolic tools to study wine body** — •Oliver Fiehn, Kirsten Skogerson, Gert Wohlgemuth

SYCH 2.4 Thu 18:00–18:30 HSZ 02 **Identification of Ancient Plant Textiles** — •Bodil Holst, Bridget Murphy

Sessions

A 1.1–1.7	Mon	10:30–13:00	BAR 205	**Interaction with VUV and X-ray light (FEL) I**
A 2.1–2.9	Mon	10:30–12:45	BAR 106	**Ultra-cold atoms, ions and BEC I (with Q)**
A 3.1–3.10	Mon	10:30–13:00	SCH 251	**Ultracold Atoms: Manipulation and Detection (with Q)**
A 4.1–4.8	Mon	14:00–16:00	BAR 205	**Precision spectroscopy of atoms and ions I**
A 5.1–5.6	Mon	14:00–16:00	BAR 106	**Photoionization I**
A 6.1–6.8	Mon	16:30–18:30	BAR 205	**Precision spectroscopy of atoms and ions II**
A 7.1–7.13	Mon	16:00–18:30	P1	**Poster I**
A 8.1–8.5	Mon	16:30–18:30	BAR 106	**Photoionization II**
A 9.1–9.7	Tue	10:30–13:00	BAR 205	**Interaction with VUV and X-ray light (FEL) II**
A 10.1–10.9	Tue	10:30–12:45	BAR 106	**Ultra-cold atoms, ions and BEC II (with Q)**
A 11.1–11.6	Tue	14:00–15:30	BAR 205	**Precision spectroscopy of atoms and ions III**
A 12.1–12.5	Tue	14:00–15:30	BAR 106	**Interaction of matter with ions I**
A 13.1–13.14	Tue	18:00–20:00	P1	**Poster II**
A 14.1–14.7	Fri	10:30–12:45	BAR 106	**Interaction with VUV and X-ray light III**
A 15.1–15.8	Wed	10:30–12:45	BAR 106	**Ultra-cold atoms, ions and BEC III (with Q)**
A 16.1–16.8	Wed	14:00–16:00	BAR 106	**Atomic systems in external fields I**
A 17.1–17.6	Wed	16:30–18:00	BAR 205	**Ultra-cold atoms, ions and BEC IV (with Q)**
A 18.1–18.8	Wed	16:30–18:30	BAR 106	**Interaction with strong or short laser pulses I**
A 19.1–19.9	Thu	10:30–13:00	BAR 205	**Atomic clusters I**
A 20.1–20.10	Thu	10:30–13:00	BAR 106	**Ultra-cold atoms, ions and BEC V (with Q)**
A 21.1–21.8	Thu	14:00–16:00	BAR 205	**Atomic systems in external fields II**
A 22.1–22.7	Thu	14:00–16:00	BAR 106	**Electron scattering and recombination I**
A 23.1–23.6	Thu	14:30–16:00	SCH A118	**Ultracold Atoms: Trapping and Cooling 1 (with Q)**
A 24.1–24.8	Thu	16:30–18:30	BAR 205	**Attosecond physics I**
A 25.1–25.7	Thu	16:30–18:30	BAR 106	**Ultra-cold plasmas and Rydberg systems I**
A 26.1–26.81	Thu	16:00–18:30	P2	**Poster III**
A 27.1–27.5	Fri	10:30–13:00	BAR 205	**Nano Plasmonic (with HL)**
A 28.1–28.8	Wed	10:30–12:45	BAR 205	**Attosecond physics II**
A 29.1–29.10	Fri	10:30–13:00	HSZ 02	**Ultracold Atoms: Trapping and Cooling 2 (with Q)**

Annual General Meeting of the Atomic Physics Division

Wednesday 13:30–14:00 BAR106

- Bericht / Report
- Wahl / Election
- Verschiedenes / Miscellaneous

A 1: Interaction with VUV and X-ray light (FEL) I

Time: Monday 10:30–13:00 Location: BAR 205

Invited Talk A 1.1 Mon 10:30 BAR 205

First results from multi-coincidence experiments at LCLS — •Daniel Rolles[1,2], Benedikt Rudek[1,3], Artem Rudenko[1,3], Benjamin Erk[1,3], Lutz Foucar[1,2], Sascha Epp[1,3], Ilme Schlichting[1,3], Lothar Strüder[1,4], Joachim Ullrich[1,2], and the CAMP collaboration[1] — [1]Max Planck Advanced Study Group at CFEL, Hamburg — [2]Max-Planck-Institut für medizinische Forschung, Heidelberg — [3]Max-Planck-Institut für Kernphysik, Heidelberg — [4]MPI Halbleiterlabor, München

The CFEL-ASG Multi-Purpose (CAMP) instrument [1] designed, built, and operated by the the Max Planck Advanced Study Group (ASG) at the Center for Free Electron Laser Science (CFEL) with its unique combination of large-area, single-photon counting pnCCD detectors and electron and ion spectrometers allows simultaneous detection of scattered and fluorescent photons, photoelectrons and photoions on a shot-by-shot basis. It was successfully commissioned at the LCLS AMO beamline in November 2009 and has since been used for fifteen experiments ranging from AMO, solid-state, surface, and plasma physics to material sciences, chemistry, and biology. Here, we focus on the experiments that took advantage of the multi-particle detection capabilities, namely electron, ion and fluorescence spectroscopy experiments on atoms, (laser-aligned) molecules, and clusters as well as diffractive imaging experiments on clusters and nanoparticles with simultaneous ion detection.

[1] L. Strüder et al., Nucl. Instr. Meth. Phys. Res. A 614 (2010) 483.

Invited Talk A 1.2 Mon 11:00 BAR 205

X-FEL induced multi-photon processes — •Bertold Krässig — Argonne National Laboratory, Argonne, IL 60439, USA

The opening of the world's first X-ray Free Electron Laser (X-FEL), the Linac Coherent Light Source (LCLS) at the SLAC National Accelerator Laboratory, marked an important milestone in the effort to probe matter at the length and time scales of atoms and molecules. Never before has it been possible to direct hundreds of x-ray photons (800 eV-8000 eV) onto every single atom at the focus of the x-ray beam during a single pulse lasting 200 fs or less. In this talk I will present results of some of the first experiments carried out at the LCLS with the goal of exploring multiphoton processes in atoms at short wavelengths. The atom of choice in these experiment was neon. We found the target atoms to become continually altered during a single x-ray pulse by absorbing multiple photons sequentially, in some cases removing all 8 valence electrons if the photon energy is below the 1s ionization threshold, or all 10 electrons if the photon energy is above the 1s ionization threshold of Ne^{9+}. At sufficiently high beam intensities and energies above the 1s ionization thresholds, both 1s electrons can be sequentially removed before Auger decay occurs. Such creation of a hollow atom leads to a temporary reduction in the probability for photoabsorption, and the reduction becomes the more prominent the longer the lifetime of the hollow atom state. Our results demonstrate how different, and in many ways complementary, X-FEL sources are as a research tool compared to traditional synchrotron radiation facilities.

Invited Talk A 1.3 Mon 11:30 BAR 205

X-ray femtochemistry: Mapping the electronic structure of molecules during chemical reactions with x-ray spectroscopy — •Philippe Wernet — Helmholtz-Zentrum Berlin für Materialien und Energie

We use ultrafast x-ray spectroscopy to map the electronic structure of molecules during chemical reactions in the gas phase and in solution. X-ray spectroscopy gives unique access to the electronic structure and hence allows for unprecedented insight into the transient states of atoms and molecules. Our recent results will be used to illustrate this: Femtosecond photoelectron spectroscopy with a high harmonic generation set up in the lab revealed new insight into the ultrafast dissociation of Br2 molecules in the gas phase. Femtosecond resonant inelastic x-ray scattering (RIXS) at the free electron laser LCLS for the first time allowed us to track both the occupied and the unoccupied valence orbitals of a molecule during dissociation. We mapped the electronic structure of Fe(CO)5 in real time during its dissociation to Fe(CO)4 and CO in solution in a symmetry-sensitive and element-selective way and locally at the Fe atom. With this and with our research on bonding and structure of water and molecules in the gas phase and in solution a perspective on chemical dynamics with ultrashort x-ray pulses from lab- and accelerator-driven short-pulse x-ray sources will be given.

A 1.4 Mon 12:00 BAR 205

Nonlinear atomic response to ultraintense and ultrashort x-ray pulses — Gilles Doumy[1,2], C. Roedig[1], •Sang-Kil Son[3], C. Blaga[1], A. DiChiara[1], A. Agostini[1], L.F. DiMauro[1], R. Santra[3,4], N. Berrah[5], C. Bostedt[6], J.D. Bozek[6], P.H. Bucksbaum[7], J. Cryan[7], L. Fang[5], S. Ghimire[7], M.J. Glownia[7], M. Hoener[5], E.P. Kanter[2], B. Krässig[2], M. Messerschmidt[6], D. Reis[7], N. Rohringer[8], and L. Young[2] — [1]The Ohio State University, USA — [2]Argonne National Laboratory, USA — [3]Center for Free-Electron Laser Science, DESY, Germany — [4]University of Hamburg, Germany — [5]Western Michigan University, USA — [6]Linac Coherent Light Source, SLAC National Accelerator Laboratory, USA — [7]PULSE Institute, SLAC National Accelerator Laboratory, USA — [8]Lawrence Livermore National Laboratory, USA

The nonlinear response of neon atoms to ultraintense, ultrashort x-ray pulses is investigated with the LCLS x-ray free-electron laser. The production of Ne^{9+} is observed at kilovolt x-ray photon energies below the absorption edge of the Ne^{8+} ground state and demonstrates a clear quadratic dependence on fluence. Theoretical analysis shows that the production is a combination of direct 2-photon ionization of the Ne^{8+} ground state and a high-order sequential process involving two 1-photon ionization processes via transient excited states on a time scale faster than the Auger decay. We find that the nonlinear 2-photon ionization cross section is orders of magnitude larger than expected.

A 1.5 Mon 12:15 BAR 205

Probing XUV FEL pulses with pump-probe autocorrelation — •Arne Senftleben[1], Moritz Kurka[1], Yuhai Jiang[1], Artem Rudenko[2], Oliver Herrwerth[3], Lutz Foucar[2], Kai-Uwe Kühnel[1], Matthias Kling[3], Stefan Düsterer[4], Claus-Dieter Schröter[1], Robert Moshammer[1], and Joachim Ullrich[1] — [1]Max-Planck-Institut für Kernphyik, Heidelberg — [2]Max-Planck Advanced Study Group at CFEL, Hamburg — [3]Max-Planck-Institut für Quantenoptik, Garching — [4]DESY, Hamburg

Using a split-mirror stage combined with a reaction microscope, autocorrelation traces of XUV pulses from the free-electron laser (FEL) at Hamburg were recorded for multiple ionization of atomic and molecular targets. Two characteristic time scales can be identified: the pulse-envelope duration and a substantially shorter coherence time. We conclude that the latter is a consequence of the internal pulse structure generated by the laser source. It is envisioned that this allows future pump-probe measurements with temporal resolution beneath the pulse duration. We reproduce and further characterise the FEL pulses using a partial-coherence model.

A 1.6 Mon 12:30 BAR 205

Novel light from high-order harmonic generation manipulated by XUV light — •Christian Buth[1], Markus C. Kohler[1], Joachim Ullrich[1,2], and Christoph H. Keitel[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Max-Planck Advanced Study Group at CFEL, 22607 Hamburg, Germany

We theoretically combine high harmonic generation (HHG) with resonant XUV excitation of a core electron into the transient valence vacancy that is created in the course of the HHG process: the first electron performs a HHG three-step process whereas, the second electron Rabi flops between the core and the transient valence vacancy. The modified HHG spectrum due to recombination with the valence and the core is determined and analyzed for krypton on the $3d \to 4p$ resonance in the ion in the light of the Free Electron Laser in Hamburg (FLASH). Our prediction offers novel prospects for nonlinear XUV physics, attosecond x rays, and tomographic imaging of core orbitals. — arXiv:1012.4930

A 1.7 Mon 12:45 BAR 205

Statistical modeling of FEL pulse shapes using a partial-coherence colored-noise approach — •Thomas Pfeifer[1], Yuhai

Jiang[1], Stefan Düsterer[2], Robert Moshammer[1] und Joachim Ullrich[1] — [1]Max-Planck Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Deutsches Elektronen-Synchrotron (DESY), Notkestrasse 85, 22605 Hamburg, Germany

Most free-electron lasers (FELs) producing intense pulses in the extreme ultraviolet (XUV) and x-ray spectral regions are currently operated in the self-amplified spontaneous emission (SASE) mode. Under these conditions, light emission starts from (quantum) noise and amplification of a light pulse occurs by a relativistic electron bunch oscillating in an undulator. This noisy origin of SASE FEL pulses results in dramatic fluctuations of pulse energy and pulse shape from shot to shot. Here, we present a simple numerical approach to model the pulse-shape statistics of such FEL pulses, even without specific knowledge of technical machine parameters such as electron bunch energy characteristics or undulator geometry. Only the measured average spectral shape and average pulse duration are required to produce sets of FEL pulse shapes for the exponential-growth ("linear") regime that fulfill statistical properties required by FEL theory. The modeled single-shot spectral shapes agree well with measured single-shot spectra. This method allows to include statistical variations of FEL pulse shapes into simulations of nonlinear FEL–matter interaction in pump–probe experiments. It will be shown that agreement of simulation results and experimental data is only achieved when pulse-shape statistics are accounted for.

A 2: Ultra-cold atoms, ions and BEC I (with Q)

Time: Monday 10:30–12:45 Location: BAR 106

A 2.1 Mon 10:30 BAR 106

Scattering of a polarizable atom by an absorbing nanowire — •Martin Fink, Johannes Eiglsperger, Harald Friedrich, and Javier Madroñero — Physik Department (T30a), TU München, Germany

In view of the intense attention currently given to systems involving nanotubes at very low temeratures, we study the fundamental process of scattering a cold, polarizable atom by an infinite cylindrical conducting wire. We formulate a method offering a practicable way of numerically calculating the exact nonretarded electrostatic van der Waals potential with any desired accuracy, see Ref. [1]. Using this method, we are able to calculate numerically the scattering properties for an absorbing nanowire by assuming incoming boundary conditions at the surface. We present calculations, e.g. of the s-wave scattering length which characterizes the behaviour of these properties in the near-threshold region. This is the first calculation of atom-wire scattering, which is based on a theoretically founded potential and on the two-dimensional nature of the problem.

[1] M. Fink et al., Physical Review A **81**, 062714 (2010).

A 2.2 Mon 10:45 BAR 106

Universality of s-wave scattering phase shifts beyond the effective-range expansion — •Alexander Kaiser, Tim-Oliver Müller, and Harald Friedrich — Physik Department, TU München, Germany

The properties of scattering states at low energies in deep potentials with a homogeneous attractive tail $V(r) = -\hbar^2\beta_\alpha^{\alpha-2}/(2\mu r^\alpha)$ with $\alpha > 2$ are strongly related to the location of the bound states just below the dissociation threshold. It has been shown that the noninteger part $\Delta_{\rm th}$ of the threshold quantum number determines the scattering length [1] as well as the semiclassical behaviour [2] of the scattering phase shift at intermediate energies. With a new method we derived a formula for the scattering phase shift, accurately describing the whole energy range from threshold to the semiclassical regime, $\tan(\delta_0) = A_s/A_c \sin(\phi_s - \phi_{\rm sr})/\cos(\phi_s - \phi_{\rm sr})$, where A_s/A_c, ϕ_s and ϕ_c are universal functions of energy, which depend on the potential tail (i.e. α) alone and $\phi_{\rm sr}$ contains a single parameter $\Delta_{\rm th}$, accounting for all short range effects. The bound states below threshold are given by the quantization function [3], $F_{\rm tail}(E_n) = n_{\rm th} - n$, so that the whole energy spectrum around the dissociation threshold is determined by the scattering length.

[1] G. Gribakin and V. Flambaum, *Phys. Rev. A* **48**, 546 (1993).
[2] G. Gribakin et al., *Phys. Rev. A* **59**, 1998 (1999).
[3] P. Raab and H. Friedrich, *Phys. Rev. A* **7**8, 022707 (2008).

A 2.3 Mon 11:00 BAR 106

Three bosons in two dimensions — •Kerstin Helfrich and Hans-Werner Hammer — HISKP(Theorie) und BCTP, Universität Bonn

In this talk I discuss two-dimensional atomic gases exhibiting a large two-body scattering length. In an effective field theory framework we are able to calculate observables up to next-to-leading order, i.e. with the inclusion of the two-body effective range. We are especially interested in three-body observables such as the binding energies, the atom-dimer scattering length and the three-body recombination rate.

A 2.4 Mon 11:15 BAR 106

Interaction Driven Interband Tunneling of Bosons in the Triple Well — •Lushuai Cao[1], Ioannis Brouzos[1], Sascha Zöllner[2], and Peter Schmelcher[1] — [1]Zentrum für Optische Quantentechnologien, Luruper Chaussee 149, D-22761 Hamburg, Germany — [2]Niels Bohr International Academy, Niels Bohr Institute, Blegdamsvej 17, DK-2100 Copenhagen, Denmark

We study the tunneling of a small ensemble of strongly repulsive bosons in a one-dimensional triple-well potential. The usual treatment within the single-band approximation suggests suppression of tunneling in the strong interaction regime. However, we show that several windows of enhanced tunneling are opened in this regime. This enhanced tunneling results from higher band contributions, and has the character of interband tunneling. It can give rise to various tunneling processes, such as single-boson tunneling and two-boson correlated tunneling of the ensemble of bosons, and is robust against deformations of the triple well potential. We introduce a basis of generalized number states including all contributing bands to explain the interband tunneling, and demonstrate various processes of interband tunneling and its robustness by numerically exact calculation.

A 2.5 Mon 11:30 BAR 106

A fundamental limit to spin-exchange optical pumping of ^{3}He nuclei — •H.R. Sadeghpour, T.V. Tscherbul, P. Zhang, and A. Dalgarno — ITAMP, Harvard-Smithsonian CfA, Cambridge, MA 02138

The existence of a fundamental limit to the efficiency of spin-exchange optical pumping of ^{3}He nuclei by collisions with spin-polarized alkali-metal atoms is established. Using accurate *ab initio* calculations of molecular interactions and scattering properties, requiring no adjustable parameters, it is demonstrated that attainable polarization of ^{3}He nuclei by spin-exchange collisions with K atoms is limited by the anisotropic hyperfine interaction. The theory is specifically applied to the spin-exchange between potassium and ^{3}He. In a complementary calculation, it is suggested that it may be possible to overcome this limit by using atomic silver (Ag) as a collision partner in spin-exchange optical pumping experiments.

A 2.6 Mon 11:45 BAR 106

Rotons and Supersolids in Rydberg-dressed BECs — •Nils Henkel and Thomas Pohl — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden

We study a BEC where atoms are off-resonantly coupled to high Rydberg states with strong van der Waals interaction. We find that this leads to effective ground state interactions which, in turn, lead to the formation of a crystalline structure in the BEC. Comparisons to Quantum Monte Carlo simulations at finite temperatures demonstrate the survival of a significant superfluid fraction, i.e. the emergence of a Supersolid state in the BEC. This excellent agreement proves the applicability of our Mean-Field theory. Therefore, we then extend our Mean-Field investigation to rotating BECs and find similar structures as in the stationary case. There appears however a nontrivial competition between supersolid order and an Abrikosov vortex lattice due to rotation. Shedding light on this competition, the resulting phase diagram will be discussed.

A 2.7 Mon 12:00 BAR 106

Mesoscopic Transport of Ultracold Atoms in Optical Lat-

tices — •Martin Bruderer and Wolfgang Belzig — Fachbereich Physik, Universität Konstanz, D-78457 Konstanz, Germany

Transport of quantum gases is attracting considerable attention, both on a theoretical and experimental level, in part because ultracold atoms confined to optical lattices can be coherently manipulated and detected on microscopic scales. In particular, substantial technological progress has opened the way for a bottom-up approach to mesoscopic transport in optical lattices, in which case the coherence in certain parts of the system is deliberately destroyed. We show based on a specific setup, namely two incoherent atomic reservoirs connected by a short optical lattice, that mesoscopic phenomena such as, e.g., phonon assisted transport, coherent suppression of tunneling and non-adiabatic quantum pumping can be realized with ultracold atoms. For our analysis in the tight-binding regime we use the non-equilibrium Green's functions formalism extended to include the time dependence of the reservoirs.

A 2.8 Mon 12:15 BAR 106

Phase diagrams for spin-1 bosons in an optical lattice — •Ming-Chiang Chung[1,2] and Sungkit Yip[2] — [1]Physics Division, National Center for Theoretical Science, Hsinchu, 30013, Taiwan — [2]Institute of Physics, Academia Sinica, Taipei 11529, Taiwan

The phase diagrams of a polar spin-1 Bose gas in a three-dimensional optical lattice with linear and quadratic Zeeman effects both at zero and finite temperatures are obtained within mean-field theory. The phase diagrams can be regrouped to two different parameter regimes depending on the magnitude of the quadratic Zeeman effect Q. For large Q, only a first-order phase transition from the nematic (NM) phase to the fully magnetic (FM) phase is found, while in the case of small Q, a first-order phase transition from the nematic phase to the partially magnetic (PM) phase, plus a second-order phase transition from the PM phase to the FM phase is obtained. If a net magnetization in the system exists, the first-order phase transition causes a coexistence of two phases and phase separation: for large Q, NM and FM phases and for small Q, NM and PM phases. The phase diagrams in terms of net magnetization are also obtained

A 2.9 Mon 12:30 BAR 106

Magnetism and Phase Separation in SU(3) Symmetric Multi-species Fermi Mixtures — •Irakli Titvinidze[1], Antonio Privitera[1,2], Soon-Yong Chang[3,4], Sebastian Diehl[3], Mikhail Baranov[3], Andrew Daley[3], and Walter Hofstetter[1] — [1]Institut für Theoretische Physik, Goethe-Universität, Frankfurt am Main, Germany — [2]Dipartimento di Fisica, Università di Roma La Sapienza, Roma, Italy — [3]IQOQI of the Austrian Academy of Sciences, Innsbruck, Austria, — [4]Department of Physics, The Ohio State University, Columbus, OH 43210, USA

We study the phase diagram of a SU(3) symmetric mixture of three-species fermions in a lattice with attractive interactions and the effect on the mixture of an effective three-body constraint induced by three-body losses. We address the properties of the system in $D \geq 2$ by using dynamical mean-field theory and variational Monte Carlo techniques. The phase diagram of the model shows a strong interplay between magnetism and superfluidity. In the absence of three-body constraint (no losses), the system undergoes a phase transition from a color superfluid phase to a trionic phase, which shows additional charge density modulations at half-filling. Outside of the particle-hole symmetric point the color superfluid phase has always a finite polarization, leading to phase separation in systems where the total number of particles in each species is conserved. The three-body constraint strongly disfavors the trionic phase, stabilizing a (fully magnetized) color superfluid phase also at strong coupling. With increase of the temperature we observe a transition to a non-magnetized $SU(3)$ Fermi liquid phase.

A 3: Ultracold Atoms: Manipulation and Detection (with Q)

Time: Monday 10:30–13:00 Location: SCH 251

A 3.1 Mon 10:30 SCH 251

Single-spin addressing in an atomic Mott insulator — •C. Weitenberg, M. Endres, J. F. Sherson, M. Cheneau, P. Schauss, T. Fukuhara, I. Bloch, and S. Kuhr — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, D-85748 Garching

The quest to address single sites of an optical lattice has a longstanding history in the field of ultracold atoms. Here we report on the achievement of full two-dimensional single-site spin control in an optical lattice with sub-diffraction limited spatial resolution. We use the differential light shift of a tightly focused laser beam to shift selected atoms into resonance with a microwave field. Starting from a Mott insulator with unity filling we are able to create arbitrary spin patterns. To demonstrate that our scheme leaves most of the atoms in the motional ground state, we observe the one-dimensional tunneling dynamics of the addressed atoms and discriminate the dynamics of the ground state and the first excited band. Our scheme opens the path to a wide range of novel applications from quantum dynamics of spin impurities, entropy transport, implementation of novel cooling schemes, and engineering of quantum many-body phases to quantum information processing.

A 3.2 Mon 10:45 SCH 251

Feedback control of the hyperfine ground states of neutral atoms in an optical cavity — •Stefan Brakhane[1], Wolfgang Alt[1], Miguel Martinez-Dorantes[1], Tobias Kampschulte[1], René Reimann[1], Artur Widera[1,2], and Dieter Meschede[1] — [1]Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, 53115 Bonn — [2]Fachbereich Physik der TU Kaiserslautern, Erwin-Schrödinger-Str., 67663 Kaiserslautern

Detection and manipulation of atomic spin states is essential for many experimental realizations of quantum gates. Feedback schemes to stabilize the states and their superpositions can counteract perturbations caused by the environment.

In our experiment we deduce the atomic spin state of one or two Caesium atoms by measuring the transmission of a probe laser through a high-finesse cavity. Depending on the number of atoms in the hyperfine state that strongly couples to the cavity, the resonance of the cavity is shifted and the probe laser transmission is decreased. We employ a Bayesian update formalism to obtain time-dependent probabilities for the atomic states of one and two atoms [1].

I will present an experimental implementation using a digital signal processor which allows us to determine the atomic spin state in real-time. First experimental results of an extension to a feedback loop for the preparation and stabilization of atomic states will be shown.

[1] S. Reick, K. Mølmer *et al.*, J. Opt. Soc. Am. B **27**, A152 (2010)

A 3.3 Mon 11:00 SCH 251

Measurement of the atom number distribution in an optical tweezer using single photon counting — •Andreas Fuhrmanek, Ronan Bourgain, Yvan Sortais, Philippe Grangier, and Antoine Browaeys — Institut d'Optique, RD 128 Campus Polytechnique, 91127 Palaiseau Cedex, France

In this talk I will present our experimental realisation of an atom counting method that allows us to reconstruct the atom number distribution inside a dipole trap and to measure the average atom number precisely. This method relies on counting single photon events on an intensified CCD camera when resonant light is sent on the atoms. We deduce the atom number distribution by analyzing the photon number distribution obtained over a series of images. This technique is a useful alternative to fluorescence or absorption methods, that may underestimate the atom number in dense samples due to photon reabsorption processes.

A 3.4 Mon 11:15 SCH 251

Imaging of microwave fields using ultracold atoms — •Pascal Böhi[1], Max Riedel[1], Theodor Hänsch[2], and Philipp Treutlein[1] — [1]Departement Physik, Universität Basel, Klingelbergstrasse 82, 4056 Basel, Switzerland — [2]Max-Planck-Institut für Quantenoptik and Ludwig-Maximilians-Universität, München, Germany

Clouds of ultracold atoms are used as highly sensitive, tunable and non-invasive probes for microwave field imaging with micrometer spatial resolution. The microwave magnetic field drives Rabi oscillations on atomic hyperfine transitions which are read out using state-selective absorption imaging. It is possible to fully reconstruct the microwave magnetic field, including the microwave phase distribution. We use this

method to determine the microwave near-field distribution around a coplanar waveguide which is integrated on an atom chip. We compare the extracted microwave field to simulations to deduce the microwave current distribution on the waveguide.
[1] P. Böhi *et al.*, Appl. Phys. Lett. **97**, 051101 (2010).

A 3.5 Mon 11:30 SCH 251

Feedback Cooling of a Single Neutral Atom — •Christian Sames, Markus Koch, Maximilian Balbach, Haytham Chibani, Alexander Kubanek, Alexei Ourjoumtsev, Pepijn Pinkse, Karim Murr, Tatjana Wilk, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, D-85748 Garching, Germany

Feedback is a powerful tool to control the evolution of classical systems. Fast electronics enables its extension towards the quantum domain, namely the control of the motion of a single neutral atom inside a high-finesse optical resonator. The atom is trapped in an optical dipole trap and interacts strongly with a single mode of the resonator. The interaction strength determines the resonance condition of the coupled system, depending on the atomic position, and hence governs the intensity of a transmitted probe beam. We analyze the flux of the transmitted photons which carries information about the atomic position and velocity, and alter the dipole force in such a way that it counteracts the atomic motion [1]. With this feedback technique we enhance the storage time of the atom in the resonator by at least 2 orders of magnitude, reaching values of more than 17 seconds with an average of more than 1 second. Additionally, we demonstrate cooling of the single atom by this technique to a temperature of about 160 μK [2]. Feedback cooling of a single atom hence rivals state-of-the-art laser cooling with the advantage that much less optical access is required.

[1] A. Kubanek et al., Nature 462, 898 (2009).
[2] M. Koch et al., Phys. Rev. Lett. 105, 173003 (2010).

A 3.6 Mon 11:45 SCH 251

Particle counting statistics of time dependent fields — •Sibylle Braungardt[1], Mirta Rodrígues[2], Aditi Sen[3], Ujjwal Sen[3], Roy J. Glauber[4], and Maciej Lewenstein[1] — [1]ICFO - Institut de Ciències Fotòniques, Av. del Canal Olímpic s/n, 08860 Castelldefels (Barcelona), Spain — [2]Instituto de Estructura de la Materia, CSIC, C/Serrano 121, 28006 Madrid, Spain — [3]Harish-Chandra Research Institute, Chhatnag Road, Jhunsi, Allahabad 211 019, India — [4]Lyman Laboratory, Physics Department, Harvard University, 02138 Cambridge, MA, U.S.A.

Since the beginnings of quantum optics, photon counting has been used as an important tool to characterize quantum states of light. The counting distribution is typically calculated using the quantum Mandel formula [1]. Likewise, the counting statistics of atoms can give insight into the quantum properties of many-body states of ultracold atomic gases. A wide range of experimental setups with cold atoms require a time and space dependent treatment of the counting process. The quantum Mandel formula treats time in a perturbative way, and generally does not give the correct behavior for time dependent systems. We derive a non-perturbative formula for the counting distribution and apply it to different experimental situations of ultracold atoms.

[1] R.J. Glauber, in Quantum Optics and Electronics, eds. B. DeWitt, C. Blandin, and C. Cohen-Tannoudji, pp. 63-185, Gordon and Breach, New York, (1965).

A 3.7 Mon 12:00 SCH 251

Shortcut to adiabatic passage in two- and three-level atoms — •Andreas Ruschhaupt — Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany

We propose a method to speed up adiabatic passage techniques in two-level and three-level atoms extending to the short-time domain their robustness. It supplements or substitutes the standard laser beam setups with auxiliary pulses that steer the system along the adiabatic path. Compared to other strategies such as composite pulses or the original adiabatic techniques, it provides a fast and robust approach to population control.

Ref.: X. Chen, I. Lizuain, A. Ruschhaupt, D. Guéry-Odelin, and J. G. Muga, Phys. Rev. Lett. 105, 123003 (2010)

A 3.8 Mon 12:15 SCH 251

Coherent control of atoms using STIRAP: Two realistic systems. — •Tadhg Morgan, Brian O'Sullivan, and Thomas Busch — Physics Department, University College Cork, Co. Cork, Ireland

Developing strategies for coherent control of quantum states is one of the keys for successful engineering of quantum mechanical structures or quantum information processors in the future. Due to the fragile nature of quantum states these techniques need to be, most importantly, fault tolerant and lead to high fidelities. One class of techniques that can achieve this are so-called adiabatic techniques and their use in optical systems has been widely investigated in the past. Recently, it has been shown that similar techniques can, in principle, be used to prepare and process quantum states of single atoms and that, in particular, the counter-intuitive STIRAP process is an excellent candidate for the coherent movement of ultra-cold atoms. As atomic traps are currently not at the technologically advanced state where they can easily be moved in space we propose two realistic setups in which STIRAP can be observed, an atomchip with three current carrying wires and triple well radio frequency potential. We show that both systems provide high fidelity STIRAP and also that the radio frequency potential allows us to extend the application of the STIRAP technique a cloud of interacting atoms.

A 3.9 Mon 12:30 SCH 251

Improved detection of small atom numbers through image processing — •Caspar Ockeloen[1,2], Atreju Tauschinksy[1], Robert Spreeuw[1], and Shannon Whitlock[1,3] — [1]University of Amsterdam, The Netherlands — [2]Universität Basel, Switzerland — [3]Universität Heidelberg, Germany

We demonstrate improved detection of small trapped atomic ensembles through advanced post-processing and optimal analysis of absorption images. These techniques provide the basis to improve the readout of trapped atom interferometers to the quantum limit or to better resolve number/spin-squeezing and entanglement between small atomic ensembles. A fringe removal algorithm reduces imaging noise to the fundamental photon-shot-noise level and proves beneficial even in the absence of fringes. A maximum-likelihood estimator is then derived for optimal atom-number estimation and is applied to real experimental data to measure the population differences and intrinsic atom shot-noise between spatially separated ensembles each comprising between 10 and 2000 atoms. The combined techniques improve our signal-to-noise by a factor of 3, to a minimum resolvable population difference of 17 atoms, close to our ultimate detection limit.

A 3.10 Mon 12:45 SCH 251

Control of refractive index and motion of a single atom by quantum interference — •Tobias Kampschulte[1], Wolfgang Alt[1], Stefan Brakhane[1], Martin Eckstein[1,2], Miguel Martinez-Dorantes[1], René Reimann[1], Artur Widera[1,3], and Dieter Meschede[1] — [1]Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, 53115 Bonn — [2]Max-Born-Institut, Abteilung A2, Max-Born-Str. 2 A, 12489 Berlin — [3]Fachbereich Physik der TU Kaiserslautern, Erwin-Schrödinger-Str., 67663 Kaiserslautern

The properties of an optically probed atomic medium can be changed dramatically by coherent interaction with a near-resonant control light field. I will present our experimental results on the elementary case of electromagnetically induced transparency (EIT) with a single neutral atom inside an optical cavity probed by a weak field [1]. We have observed modification of the dispersive and absorptive properties of a single atom by changing the frequency of the control light field in the off-resonant regime.

In this regime, the creation of a transparency window close to a narrow absorption peak can give rise to a sub-Doppler cooling mechanism. I will present the observation of strong cooling and heating effects in the vicinity of the two-photon resonance. The cooling increases the storage time of our atoms twenty-fold to about 16 seconds. Recent investigations of this effect outside the cavity using microwave sideband spectroscopy have revealed that a large fraction of atoms is cooled to the axial ground state of the trap.

[1] T. Kampschulte *et al.*, Phys. Rev. Lett. **105**, 153603 (2010)

A 4: Precision spectroscopy of atoms and ions I

Time: Monday 14:00–16:00 Location: BAR 205

A 4.1 Mon 14:00 BAR 205

Absolute determination of X-ray transition energies in H-like and He-like ions — •Katharina Kubicek, Hjalmar Bruhns, Johannes Braun, José R. Crespo López-Urrutia, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

We present high-precision wavelength measurements for H- and He-like ions performed with the FLASH-EBIT using a flat crystal x-ray spectrometer applying a collimation-free technique [Braun *et al.*, Rev. Sci. Instrum. 76 (2005), p. 073105] which allows to determine absolute Bragg angles without the need of reference lines. We have reduced further the already small leading experimental uncertainty [Bruhns *et al.*, Phys. Rev. Lett. 99 (2007), p. 113001] by installing the spectrometer coaxially to the electron beam, thus viewing the ion cloud as a point source. This setup reveals a minute curvature of the x-ray lines on the detector plane which hitherto had to be estimated. Results for the Lyman-α_1 and "w" ($1s2p\ ^1P_1 \rightarrow 1s^2\ ^1S_0$) transition wavelengths in H-like and He-like argon, sulfur and iron ions with experimental uncertainties of esimated $\Delta E < 4$ meV are sensitive to the far larger QED contributions of 1 eV.

A 4.2 Mon 14:15 BAR 205

Laser Spectroscopy on Highly Charged Fe^{13+} Ions — •Kirsten Schnorr, Volkhard Mäckel, José Ramón Crespo López-Urrutia, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

We report on the first successful laser spectroscopic measurements on highly charged Fe^{13+} trapped in an Electron Beam Ion Trap (EBIT) at MPIK. The forbidden M1 transition $(1s^2 2s^2 2p^6 3s^2 3p)\ ^2P_{3/2} - \ ^2P_{1/2}$ has been excited resonantly with a tunable dye laser, while monitoring the fluorescence photons.

The studied line is the well-known *green coronal line* of Fe XIV, and therefore of great interest for comparison with astronomical data, since our measured wavelength is not affected by the Doppler shift.

Compared to our earlier results on Ar^{13+} ions, we have been able to enhance the resolution of the method and improve evaporative cooling. The Zeeman splitting of the transition due to the magnetic field in the EBIT has been clearly resolved. In addition we have observed optical pumping between the $\pi^{1/2}$ and $\pi^{3/2}$ Zeeman levels.

A 4.3 Mon 14:30 BAR 205

Ion trapping and laser cooling in the SPECTRAP experiment — •Zoran Andjelkovic[1,3], Shailen Bharadia[2], Radu Cazan[1,3], Richard Thompson[2], Manuel Vogel[1], and Wilfried Nörtershäuser[1,3] — [1]Gesselschaft für Schwerionenforschung, Darmstadt, Germany — [2]Imperial College, London, UK — [3]Universität Mainz, Germany

As one of the experiments associated to the HITRAP project at GSI, Darmstadt, the SPECTRAP experiment is making its first steps towards precision spectroscopy on trapped highly charged ions. As an initial test, Mg+ ions are produced externally and guided into the trap, located inside a split-coil superconducting magnet, with radial optical ports for fluorescence detection. Using a frequency-quadrupled 1118 nm fibre laser they can be laser cooled to a few mK and used for sympathetic cooling of any other ion species simultaneously trapped. This report presents the trapping technique and the methods used for detecting, cooling and manipulating the ions inside the trap, together with the first experimental results.

A 4.4 Mon 14:45 BAR 205

Commissioning of HITRAP - A Decelerator for Heavy Highly-Charged Ions — •Nicolaas P.M. Brantjes, Frank Herfurth, Ludwig Dahl, Oliver Kester, and Wolfgang Quint — GSI, Darmstadt, Germany

Heavy, highly-charged ions (HCI) with only one or few electrons are interesting systems for precision experiments as for instance tests of the theory of quantum electrodynamics (QED). To achieve high precision, kinetic energy and spatial position of the ions have to be well controlled. This is in contradiction to the production process that employs stripping of ele ctrons at high energies by sending relativistic highly-charged ions with still m any electrons through matter. In order to match the production at 400 MeV/u with the requirements of the exper iments - stored and cooled HCI at low energy - the linear decelerator facility H ITRAP has been built at the experimental storage ring (ESR) at GSI in Darmstadt. The ions are first decelerated in the ESR from 400 to 4 MeV/u, cooled and extrac ted. The ion beam phase spaces are then matched to an IH-structure, decelerated from 4 to 0.5 MeV/u before a 4-rod RFQ reduces the energy to 6 keV/u. Finally, the HCI are cooled in a Penning trap to 4 K. Here we present our progress in the commissioning of the IH-Structure and the RFQ over the past year.

A 4.5 Mon 15:00 BAR 205

Spectroscopic reference for the measurement of the transition frequency of highly charged bismuth ions — Sanah Altenburg[1], •Sebastian Albrecht[1], Gerhard Birkl[1], and the SPECTRAP collaboration[2] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, Schlossgartenstraße 7, 64289 Darmstadt — [2]GSI, Planckstraße 1, 64291 Darmstadt

The investigation of the ground state hyperfine splitting of highly charged ions is one of the objectives of the experiments planned to be carried out within the SPECTRAP collaboration within the HITRAP facility at GSI. For ^{209}Bi^{82+} ions, transitions between hyperfine ground states can be exited using light at 243.9 nm. This light is produced in a laser system and two frequency-doubling stages resulting in 15 mW in the UV.

The expected wavelength of the transition between the hyperfine ground states is located near previously measured resonances of the 1S-2S transitions of muonium, deuterium and hydrogen. For those earlier measurements some molecular resonances of tellurium vapour have been calibrated with sub-Megahertz precision. These references can be used to create new references in the regime of the expected bismuth transition.

The spectrum between these calibrated resonances has been measured with an accuracy corresponding to the one of our laser system. In our presentation we describe the technique used and the performance reached.

A 4.6 Mon 15:15 BAR 205

Nuclear corrections to the g-factor of a bound electron — •Jacek Zatorski[1], Zoltan Harman[1,2], Christoph H. Keitel[1], Birgit Schabinger[3], Sven Sturm[3], Anke Wagner[3], and Klaus Blaum[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]ExtreMe Matter Institute EMMI, 64291 Darmstadt, Germany — [3]Institut für Physik, Johannes Gutenberg-Universität, 55099 Mainz, Germany

The g-factor of a bound electron has recently gained a lot of experimental as well as theoretical interest. Comparison between theoretical and experimental results for $^{12}C^{5+}$ and $^{16}O^{7+}$ led to the determination of the most accurate value of the electron mass [1]. Upcoming experiments [2] with the somewhat heavier ions Si^{13+} and Ca^{19+} and beyond are expected to achieve an even greater accuracy, which in turn will call for accordingly more accurate theoretical predictions. We present theoretical results for medium-Z hydrogen-like ions with an emphasis on effects arising due to the nuclear structure.

[1] P. J. Mohr *et al.*, Rev. Mod. Phys. **80**, 633 (2008).
[2] S. Sturm *et al.*, J. Phys. B: At. Mol. Opt. Phys. **43**, 074016 (2010).

A 4.7 Mon 15:30 BAR 205

QED in strong fields: hyperfine structure and g factor in heavy ions — •Andrey Volotka[1,2], Dmitry Glazov[2], Vladimir Shabaev[2], Ilya Tupitsyn[2], and Günter Plunien[1] — [1]Institut für Theoretische Physik, TU Dresden, Germany — [2]St. Petersburg State University, Russia

Investigations of the hyperfine splitting and g factor in highly charged ions provide access to a test of bound-state QED in strongest electromagnetic field available for experimental study. To date, accurate measurements of the ground-state hyperfine structure and of the g factor were performed in several H-like heavy ions and in H-like carbon and oxygen ions, respectively. An extension of such kind of experiments to highly charged Li-like ions will provide the possibility to investigate a specific difference between the corresponding values for H- and Li-like ions, where the uncertainty due to the nuclear effects can be substantially reduced. In this talk we present ab initio QED calculations of the hyperfine splitting and g factor of heavy high-Z ions. Special attention is focused on recent results of our rigorous evaluation of the complete gauge-invariant set of the screened one-loop QED corrections to the hyperfine structure and g factor in highly charged Li-like ions. The current status of the evaluations of the two-photon exchange corrections is also reported. As a result, the specific difference between the ground-state hyperfine splitting values of H- and Li-like Bi ions and for the g factor of the Li-like Pb ion are presented.

A 4.8 Mon 15:45 BAR 205

Bound electron g-Factor Measurement by Double-Resonance Spectroscopy on a Fine-Structure Transition — •David von Lindenfels[1,2,3], Wolfgang Quint[1,2], Manuel Vogel[1], and Gerhard Birkl[4] — [1]GSI Darmstadt, Germany — [2]Universität Heidelberg, Germany — [3]MPIK Heidelberg, Germany — [4]TU Darmstadt, Germany

Precise determination of bound-electron g-factors in highly-charged ions (e.g. boron-like argon Ar^{13+} and calcium Ca^{15+}) provides a stringent test of bound-state QED in extreme fields and contributes to the determination of fundamental constants. We have designed a cryogenic trap assembly with a creation trap and a spectroscopy trap. Argon ions are produced by electron impact ionization and transferred to the spectroscopy trap. We will excite the fine-structure transition $2^2P_{1/2}$ – $2^2P_{3/2}$ with laser radiation and probe microwave transitions between Zeeman sub-levels (laser-microwave double-resonance technique). From this the electronic g-factor g_J can be determined on a ppb level. We have developed and tested a field emission electron source, a novel cryogenic gas valve and an optical setup to detect the low fluorescence signal of the magnetic dipole transition. In future, the trap will be connected to the HITRAP beamline at GSI, and the method will be applied to hyperfine-structure transitions of hydrogen-like heavy ions in order to measure electronic and nuclear magnetic moments. The contribution presents techniques and the current status of the experiment.

A 5: Photoionization I

Time: Monday 14:00–16:00 Location: BAR 106

Invited Talk A 5.1 Mon 14:00 BAR 106

New insights in molecular photoionization physics - Coherence properties of the valence photoionization of N_2 and O_2 — •Jens Viefhaus[1], Markus Ilchen[1], Sascha Deinert[1], Leif Glaser[1], Frank Scholz[1], Peter Walter[1], Markus Braune[2], André Meissner[2], Lokesh Tribedi[2,3], and Uwe Becker[2] — [1]DESY, Hamburg, Germany — [2]Fritz-Haber-Institut, Berlin, Germany — [3]Tata Institute of Fundamental Research, Mumbai, India

New Synchrotron Radiation sources such as the "Variable Polarization XUV beamline P04" at PETRA III (DESY, Hamburg) which is presently under construction enable new classes of photoionization experiments. The main characteristics of these beamlines are exceptionally high resolution which well exceeds a resolving power of 10,000 combined with high photon flux "up to 1012 photons per second" and variable polarization properties over a very wide energy range (200-3000 eV in the case of P04 at PETRA III). This allows both to address long standing discussions in photoionization physics such as the two-center interferences in N_2 and O_2 [1] with high precision over a broad energy range as well as to perform systematic low signal coincidence studies of e.g. the coherence properties of small molecules [2]. Results of exploratory experiments performed at BESSY (HZB, Berlin) and DORIS (DESY, Hamburg) on the valence photoionization of N_2 and O_2 will be presented and compared with theory [1,3]. In addition an overview on recent experimental developments at different synchrotron radiation centers will be given.

[1] H. D. Cohen and U. Fano, Phys. Rev. **150**, 30 (1966).
[2] B. Zimmermann et al., Nature Phys. **4**, 649 (2008).
[3] D. Toffoli, P. Decleva, J. Phys. B **39**, 2681 (2006).

Invited Talk A 5.2 Mon 14:30 BAR 106

Appearance of coherent localization due to the Auger Doppler effect — •Burkhard Langer[1], Rainer Hentges[2], Oliver Kugeler[3], Markus Braune[2], Sanja Korica[2], Jens Viefhaus[2], Daniel Rolles[2], Uwe Hergenhahn[3], Hironobu Fukuzawa[4], Xiaojing Liu[4], Yusuke Tamenori[5], Masamitsu Hoshino[6], Hiroshi Tanaka[6], Christophe Nicolas[7], Catalin Miron[7], Omar Al-Dossary[8], Kiyoshi Ueda[4], and Uwe Becker[2,8] — [1]Freie Universität Berlin — [2]Fritz-Haber-Institut, Berlin — [3]Institut für Plasma Physik, Garching — [4]Tohoku University, Sendai — [5]Japan Synchrotron Radiation Research Institute, Hyogo — [6]Sophia University, Tokyo — [7]Synchrotron SOLEIL, France — [8]King Saud University, Riyadh

Homouclear diatomic molecules are inversion symmetric systems which form eigenstates of the parity operator known as *gerade* and *ungerade* states. These states are non-local superpositions of charge distributions on both nuclear sites of the molecule with a phase shift of 0 and π, respectively. Due to this intrinsic character a coherent superposition of these states generates a localized state either on the left or on the right side. Such a coherent superposition of two parity eigenstates with different symmetries occurs on top of the broad $3\sigma_u$ shape resonance of O_2 because the narrow $3s\sigma_g$ Rydberg excitation is sitting just near its maximum. This gives rise to interference causing coherent localization of the emitter position of the autoionizing electron. As a result of this localization the two Doppler components of the corresponding electron have unequal intensities, the so called wrong component has half of the right component only. This unexpected experimental result could be confirmed by a numerical simulation which takes known values of the decay life time, the splitting of the excited symmetry states and the conical intersection of the corresponding potential curves into account. The result is in perfect agreement with the measurements.

A 5.3 Mon 15:00 BAR 106

X-ray Photoelectron Spectroscopy of Free Silicon Dioxide Nanoparticles near the Si 2p Absorption Edge — •Egill Antonsson[1], Burkhard Langer[1], Johan Söderström[2], Christophe Nicolas[2], Olivier Sublemontier[3], Xiojing Liu[2], Christina Graf[1], Peter Schmiel[1], Ghassen Saidani[4], Jean-Luc Le Garrec[4], Emmanuel Robert[2], James Brian Mitchell[4], Paul Morin[2], Cécile Reynaud[3], Catalin Miron[2], and Eckart Rühl[1] — [1]Institut für Chemie und Biochemie, Freie Universität Berlin, Germany — [2]Synchrotron SOLEIL, Gif-sur-Yvette, France — [3]Laboratoire Francis Perrin, Gif-sur-Yvette, France — [4]University of Rennes, Rennes, France

The physical and chemical properties of nanoparticles are a subject of great interest. Their unique properties are often related to their high surface-to-bulk ratio. In order to study the intrinsic properties of nanoparticles free from interactions with any surrounding medium, we have used aerodynamic focusing to form a beam of nanoparticles in high vacuum. We have studied the photoemission from silicon dioxide nanoparticles (diameter: 50-200 nm) after excitation near the Si 2p absorption edge over a wide electron-kinetic-energy range. This reveals contributions from direct photoelectrons, Auger electrons, inelastically scattered electrons, and Auger electron channels as well as slow secondary electrons. Specific attention is given to electron-electron coincidence events involving emission of two electrons. The emission of two secondary electrons is the most common process involving emission of two electrons.

A 5.4 Mon 15:15 BAR 106

Origin of Low Energy Structures in Photoelectron Spectra Induced by Mid-Infrared Strong Laser Fields — •Liu Chengpu and Hatsagortsyan Karen Z. — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

Based on a semiclassical model incorporating tunneling and Coulomb field effects, the origin of the low-energy structures (LES) in above-threshold ionization spectrum observed in recent experiments [1] is identified. Following a systematic investigation how the LES depend on laser polarization, pulse duration and the atomic potential range, we classified and quantified the Coulomb effects. We proved that the non-perturbative contribution of the multiple forward scattering into Coulomb focusing is responsible for the appearance of LES [2]. The shape of the LES is due to the interplay between multiple forward scattering of an ionized electron and the electron momentum disturbance by the Coulomb field immediately after the ionization determine. The former determines the appearance of the LES, while the latter does the positions of the LES peaks. The dependence of the LES height and width on the laser intensity or wavelength is also investigated and a simple scaling law is derived.

[1] C. I. Blaga et al., Nature Phys. 5, 335 (2009); W. Quan et al., Phys. Rev. Lett. 103, 093001 (2009).

[2] C. Liu and K. Z. Hatsagortsyan, Phys. Rev. Lett. 105, 113003 (2010).

A 5.5 Mon 15:30 BAR 106

NO^+ fluorescence in the visible spectral range after excitation of the $1s^{-1}2\pi^2$ resonances with synchrotron radiation — •Benjamin Kambs, André Knie, and Arno Ehresmann — Universität Kassel, Institut für Physik und Center for Interdisciplinary Nanostructure Science and Technology, Heinrich Plett Str. 40, 34132 Kassel, Germany

Fluorescence spectra after deexcitation of different vibrational levels of the NO^+ $A^1\Pi$-term have been measured with photon induced fluorescence spectroscopy (PIFS) in the spectral range of 420-480 nm.

The excitation was performed with synchrotron radiation from the UE56/2 PGM2 beamline at BESSY II in the energy range of 397-400 eV.

Intensities of fluorescence radiation have been measured horizontally and vertically with respect to the polarization vector of the exciting radiation. Therefore the angular distribution parameter β can be calculated. Its energy dependency was used to verify the influence of symmetry forbidden electronic state interference (ESI) on the population of the NO^+ $A^1\Pi$-term via symmetry different, resonant intermediate electronic states.

A 5.6 Mon 15:45 BAR 106

Photoelectron Time-of-Flight Spectroscopy in a hard X-ray Regime — •Markus Ilchen[1], Sascha Deinert[1], Leif Glaser[1], Frank Scholz[1], Jörn Seltmann[1], Peter Walter[1], and Jan Grünert[2] — [1]Deutsches Elektronen Synchrotron, Notkestraße 85, 22609 Hamburg — [2]European XFEL, Albert-Einstein-Ring 19, 22761 Hamburg

Using photoelectron time-of-flight spectroscopy for the determination of several Synchrotron and FEL beam properties is a well characterized method for the soft X-ray regime. Upcoming and already working XFEL facilities as well as hard X-ray photon beamlines at Synchrotron Radiation facilities like PETRA III at DESY are also highly interested in online beam diagnostics in terms of beam positioning, energy, flux and the degree of photon polarization. The energy range in which this method is successfully tested was increased from the soft X-ray regime up to 15 keV. Not only diagnosis but also angle resolved photoelectron spectroscopy of rare gases like Argon, Krypton and Xenon were performed in that energy range at the P09 beamline at PETRA III. The actual status of the developed spectrometer, the latest measurements for polarization determination as well as the angular distribution of Xe 2p electrons from threshold up to 7 keV will be presented. Adaptability to XFELs in terms of shot to shot polarization analysis and relevant technical issues will be discussed.

A 6: Precision spectroscopy of atoms and ions II

Time: Monday 16:30–18:30 Location: BAR 205

A 6.1 Mon 16:30 BAR 205

Status of the HITRAP cooler Penning trap. — •Svetlana Fedotova[1], Nikolaas Brantjes[1], Frank Herfurth[1], Nikita Kotovskiy[1], Claude Krantz[2], Giancarlo Maero[3], Wolfgang Quint[1], Mouwafak Shaaban[1], Alexey Sokolov[1], and Jochen Steinmann[1] — [1]GSI Helmholtzzentrum für Schwerionenforshung, Darmstadt — [2]Heidelberg University — [3]University of Milano

HITRAP is a facility at GSI, Darmstadt for decelerating, cooling and storing of heavy, highly-charged ions. Bunches of up to 10^5 ions at 6 keV/u, as heavy as U92+, will be injected into the Penning trap for cooling first with electrons and then resistively. Extracted from the trap at low-energy, either quasi-continuous or bunched, ions will be delivered to high-precision atomic physics experiments. The trap is installed into the cold bore of a cryogen-free, 6 T superconducting magnet. Extensive cool down tests provided that the trap electrodes temperature reaches about 10 K which is the temperature the ions are cooled to using resistive cooling. Bunches of 10^{10} electrons can be injected into the trap from an electron source installed downstream. The electrostatic potentials of the trap electrodes will be arranged to form a nested trap in order to allow capture both, ions and electrons, simultaneously inside the trap. The sequence of the different processes: electron injection, ion capture in flight, electron and resistive cooling, controlled ejection - requires a sophisticated control system and extensive simulations. The most recent simulations investigate, for instance, the conditions under which the energy spread can be kept low during continuous ejection.

A 6.2 Mon 16:45 BAR 205

Test der Zeitdilatation mit $^7Li^+$-Ionen bei einer Geschwindigkeit von 0,338 c — •Benjamin Botermann[1,2], Christopher Geppert[1,2], Gerhard Huber[1], Sergei Karpuk[1], Wilfried Nörtershäuser[1,2], Rodolfo Sanchez[1,2], Thomas Kühl[2], Christian Novotny[2], Thomas Stöhlker[2], Dennis Bing[3], Dirk Schwalm[3], Andreas Wolf[3], Gerald Gwinner[4], Theodor W. Hänsch[5], Sascha Reinhardt[5] und Guido Saathoff[5] — [1]Johannes Gutenberg-Universität Mainz, Mainz — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [3]MPI für Kernphysik, Heidelberg — [4]University of Manitoba, Winnipeg, Canada — [5]MPI für Quantenoptik, Garching

Für einen Test der Zeitdilatation wird nach dem Vorbild des Ives-Stilwell Experimentes die Frequenz eines elektromagnetischen Dipolübergangs an schnellen Ionen gemessen und mit den Vorhersagen der Speziellen Relativitätstheorie (SRT) verglichen. Am GSI Helmholtzzentrum für Schwerionenforschung werden dafür metastabile $^7Li^+$-Ionen bei einer Geschwindigkeit von 0,338 c gespeichert und mit Laserstrahlen überlagert. Mit dopplerfreien Spektroskopieverfahren konnte die Übergangsfrequenz bei dieser Geschwindigkeit auf 1 MHz genau bestimmt werden. Dies erlaubt einen Test des Zeitdilatationsfaktors γ, mit einer gegenüber vorherigen Experimenten [1,2] um einen Faktor 2 verbesserten Genauigkeit von 10^{-8}. Wir präsentieren die Ergebnisse der jüngsten Messungen an der GSI.

[1] S. Reinhardt et al. *Nat. Phys.* **3** (2007) 861.

[2] C. Novotny et al. *PRA* **80** (2009) 022107.

A 6.3 Mon 17:00 BAR 205

Messung von Einsteinkoeffizienten mittels absorptiver und dispersiver Atom-Licht Wechselwirkung — Ulrich Poschinger[1], •Max Hettrich[1], Frank Ziesel[1], Andreas Walther[1], Markus Deiss[2] und Ferdinand Schmidt-Kaler[1] — [1]Institut für Physik, Universität Mainz — [2]Institut für Quantenmaterie, Universität Ulm

Während atomare Übergangsfrequenzen mittlerweile sehr genau vermessbar sind, ist dies für die Lebensdauern von angeregten Zuständen nicht der Fall.

Die hier vorgestellte, vollkommen neuartige Methode zur Messung von Einsteinkoeffizienten atomarer Ionen beruht auf Methoden der Quanteninformationsverarbeitung, wie der genauen Messung von AC-Lichtverschiebungen sowie der Zustandspräparation und -auslese mit hoher Güte. Mit nichtresonanten Laserfeldern werden dispersive und absorptive Atom-Licht Wechselwirkungen induziert. Aus der sich ergebenden Populationsdynamik der beteiligten Zustände lassen sich dann die gesuchten Übergangsraten ermitteln. In Experimenten konnten wir so die Zerfallsrate des $4^2S_{1/2}$ - $4^2P_{1/2}$ Übergangs an einzelnen $^{40}Ca^+$ Ionen sowie das Verzweigungsverhältnis zwischen dem $4^2S_{1/2}$ und dem $3^2D_{3/2}$ Zustand bestimmen.

Die verwendete Methode ist jedoch keineswegs auf $^{40}Ca^+$ beschränkt und eröffnet so die Möglichkeit, auch Dipolmatrixelemente anderer Übergänge oder Ionenspezies zu messen.

A 6.4 Mon 17:15 BAR 205

Eine neue verbesserte Messmethode der reduzierten Zyklotronfrequenz für den *g*-Faktor des gebundenen Elektrons in hochgeladenen Ionen — •Anke Wagner, Sven Sturm, Birgit Schabinger und Klaus Blaum — MPI für Kernphysik, D-69117 Heidelberg, Germany

Hochpräzisionsmessungen des gyromagnetischen Faktors (g-Faktors) eines gebundenen Elektrons ermöglichen einen sehr genauen Test von Rechnungen zur Quantenelektrodynamik gebundener Zustände (BS-QED). Der g-Faktor kann durch die Messung der freien Zyklotronfrequenz und der Larmor-Spinpräzessionsfrequenz bestimmt werden. Um die freie Zyklotronfrequenz zu erhalten, werden die drei Eigenfrequenzen eines Ions in einer Penningfalle bestimmt. Hierbei muss die reduzierte Zyklotronfrequenz mit der höchsten Genauigkeit bestimmt werden. Im letzten Jahr wurde eine neue verbesserte Messmethode entwickelt, die durch eine phasensensitive Messung der reduzierten Zyklotronfrequenz bei sehr niedrigen Zyklotronenergien gleichzeitig eine zehnmal genauere und zwölfmal schnellere Messung als früher ermöglicht. Dies versetzt uns in die Lage den g-Faktor mit einer Genauigkeit besser als 100 ppt zu bestimmen. Das Prinzip der neuen Messmethode sowie erste Ergebnisse werden vorgestellt.

A 6.5 Mon 17:30 BAR 205

Hochpräzise g-Faktor Messungen an hochgeladenen Ionen — •Sven Sturm, Anke Wagner, Birgit Schabinger, Klaus Blaum, Jacek Zatorski, Zoltán Harman und Christoph H. Keitel — MPI für Kernphysik, D-69117 Heidelberg, Germany

Hochpräzisionsmessungen des gyromagnetischen Faktors (g-Faktor) eines gebundenen Elektrons ermöglichen einen sehr genauen Test von Rechnungen zur Quantenelektrodynamik gebundener Zustände (BS-QED). Der g-Faktor kann durch die Messung der freien Zyklotronfrequenz und der Larmor-Spinpräzessionsfrequenz bestimmt werden. Um die freie Zyklotronfrequenz zu erhalten, werden die drei Eigenfrequenzen eines Ions in einer Penningfalle bestimmt. Im letzten Jahr wurden erste Messungen mit dem weiterentwickelten Fallensystem durchgeführt. Diese Ergebnisse werden vorgestellt sowie ein Ausblick auf das weitere Messprogramm und die Möglichkeiten zur Bestimmung von Fundamentalkonstanten gegeben.

[1] H. Häffner *et al.*, Phys. Rev. Lett. **85**, 5308 (2000)
[2] J. Verdú *et al.*, Phys. Rev. Lett. **92**, 093002 (2004)
[3] B. Schabinger *et al.*, J. Phys. Conf. Ser. **163**, 012108 (2009)
[4] M. Vogel *et al.*, Nucl. Inst. Meth. B **253**, 7 (2005)

A 6.6 Mon 17:45 BAR 205

Status des Experiments zur Bestimmung des g-Faktors des Protons in einer Penning-Falle — •Holger Kracke[1], Klaus Blaum[2,3], Andreas Mooser[1], Wolfgang Quint[4], Cricia Rodegheri[1], Stefan Ulmer[1,2,4] und Jochen Walz[1] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz — [2]Max-Planck-Institut für Kernphysik, 69117 Heidelberg — [3]Ruprecht-Karls-Universität, 69047 Heidelberg — [4]GSI Darmstadt, 64291 Darmstadt

Ziel des Experiments ist die erste direkte Bestimmung des g-Faktors des Protons mit einer Genauigkeit von 10^{-9} in einem Doppel-Penningfallen-System. Der g-Faktor lässt sich aus dem Verhältnis der freien Zyklotronfequenz ν_c und der Larmorfrequenz ν_L gemäβ $g = 2\frac{\nu_L}{\nu_c}$ berechnen. Die Ermittlung der Larmorfrequenz ν_L erfolgt mit Hilfe des kontinuierlichen Stern-Gerlach-Effekts durch die Verwendung einer ferromagnetischen Ringelektrode in der sogenannten Analysefalle, die eine Verzerrung der Magnetfeldlinien verursacht. Diese Inhomogenität des Feldes (magnetische Flasche) ermöglicht die Kopplung zwischen dem magnetischen Moment des Protons und seiner axialen Frequenz, so dass ein Umklappen des Spins sich als Frequenzverschiebung von 10^{-7} bemerkbar macht. Die benötigte magnetische Flasche von 300 mT/mm^2 erschwert die Speicherung des Protons, da die axiale Frequenz somit auch sehr sensitiv auf Veränderungen der Quantenzahlen der radialen Moden ist. Die erstmalige Detektion eines geladenen Teilchens in einer magnetischen Flasche dieser Stärke, sowie Messungen zur Stabilität werden präsentiert.

A 6.7 Mon 18:00 BAR 205

Kollineare Laserspektroskopie zur Untersuchung des Halo-Charakters des kurzlebigen Isotops 12Be — •Ch. Geppert[1,2], A. Krieger[2], R.M. Sanchez Alarcon[2], N. Frömmgen[1], M. Hammen[1], J. Krämer[1], M.L. Bissell[3], K. Blaum[4], M. Kowalska[5], K. Kreim[4], R. Neugart[1], W. Nörtershäuser[1,2], C. Novotny[1,2] und D.T. Yordanov[5] — [1]Universität Mainz — [2]GSI Darmstadt — [3]Katholieke Universiteit Leuven — [4]MPI für Kernphysik Heidelberg — [5]ISOLDE, CERN

Der Einsatz eines Frequenzkamms hat es vor zwei Jahren erstmals ermöglicht, die Isotope sehr leichter, kurzlebiger Isotope mittels kollinearer Laserspektroskopie zu untersuchen. So konnte durch die Messung der Isotopieverschiebungen der Beryllium-Isotope 7,9,10,11Be der Ladungsradius des Halo-Nuklids 11Be mit einem relativen Fehler von $< 1\%$ bestimmt werden. Nun wurde die Untersuchung der Isotopenkette auf das Isotop 12Be ausgeweitet. Voraussetzung für diese Messungen waren Untersuchungen zu systematischen Einflüssen des Photonenrückstoßes und die Reduktion des Streulichtuntergrunds durch Photonen-Ionen Koinzidenzen. Die Untersuchung von 12Be ist insbesondere interessant, da neue Streuexperimente an der GSI in Darmstadt erstmals einen ausgeprägten Halo-Charakter von 12Be zeigen, was im Widerspruch zu früheren Untersuchungen steht. Die Laserspektroskopie liefert hier einen modellunabhängigen Zugang zum Ladungsradius. Eine erste Auswertung der 2010 an ISOLDE gewonnen Daten der kollinearen Laserspektroskopie werden vorgestellt und liefern eine komplementäre Information zum Halo-Charakter von 12Be.

A 6.8 Mon 18:15 BAR 205

First measurement of the ionization potential of astatine — •Sebastian Rothe[1,2], Andrei N. Andreyev[3], Stano Antalic[4], Thomas E. Cocolios[1], Dimitry V. Fedorov[5], Lars Ghys[6], Mark Huyse[6], Yuri Kudryavtsev[6], Jens Lassen[7], Bruce A. Marsh[1], Dieter Pauwels[6], Deyan Radulov[6], Sebastian Raeder[2], Maxim Seliverstov[5,6], A. Marica Sjödin[1], Piet Van Duppen[6], Martin Venhart[8], Klaus Wendt[2], and Valentin N. Fedosseev[1] — [1]CERN, Geneva, Switzerland — [2]Institut für Physik, Uni Mainz, Germany — [3]University of the West of Scotland, Paisley, UK — [4]Comenius University, Bratislava, Slovakia — [5]PNPI, Gatchina, Russia — [6]IKS, KU Leuven, Belgium — [7]TRIUMF, Vancouver, Canada — [8]Slovak Academy of Sciences, Bratislava, Slovakia

Since the discovery of element 85 in the year 1940 by D. R. Corson et al., the binding energy of the outer electron of astatine had not been determined. At the on-line isotope separator facility ISOLDE at CERN, Geneva radioactive isotopes of At were produced by impinging 1.4 GeV protons on a uranium carbide target, ionized using the Resonance Ionization Laser Ion Source (RILIS) and detected using alpha decay spectroscopy. In-source laser spectroscopy was performed in order to develop a multi-step ionization scheme for an efficient and highly selective At ion production, as requested by ISOLDE users. Two atomic transitions, previously observed by absorption spectroscopy were confirmed and assigned as first steps of the excitation and ionization scheme. A second laser beam was applied to non-resonantly ionize the excited At atoms. A wavelength scan of the ionizing step was performed to search for the ionization limit. From the observed ionization onset the first ionization potential of At was preliminary determined to be 9.3 eV. Results from these studies at CERN and consecutive measurements at TRIUMF, Canada and IKS, Belgium will be presented.

A 7: Poster I

Time: Monday 16:00–18:30 Location: P1

A 7.1 Mon 16:00 P1

Parity-Violation in Hydrogen: Precision Enhancement through Many-Particle Squeezing — •Martin-Isbjörn Trappe, Thomas Gasenzer, and Otto Nachtmann — Institut für Theoretische Physik, Heidelberg

We discuss the propagation of hydrogen atoms in static electric and magnetic fields in a longitudinal atomic beam spin echo (lABSE) Interferometer. The atoms acquire geometric (Berry) phases that exhibit a manifestation of parity-(P-)violation effects arising from electroweak Z-boson exchange between electron and nucleus. We provide analytical as well as numerical calculations of the behaviour of the metastable n=2 states of hydrogen. Possible measurements of P-violating geometric phases in lABSE experiments require a high precision for detecting atoms in specific states. We investigate possibilities to enhance the precision of lABSE experiments beyond the standard quantum limit using squeezed many-particle hydrogen states.

A 7.2 Mon 16:00 P1

Hartree-Fock calculations of the photoionization of light to medium atoms and ions in neutron star magnetic fields — Peter Diemand, Thorsten Kersting, •Damir Zajec, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart

Using the method described in the talk by Diemand et al., we determine the photoionization cross section in dipole approximation for light to medium atoms and ions in neutron star magnetic field strengths. Continuum states are treated in adiabatic approximation in a self-consistent way. Bound states are calculated by solving the Hartree-Fock-Roothaan equations using finite-element and B-spline techniques. The data are of importance for the quantitative interpretation of observed X-ray spectra that originate from the thermal emission of isolated neutron stars. They can serve as input for modelling neutron star atmospheres with regard to chemical composition, magnetic field strength, temperature and redshift.

A 7.3 Mon 16:00 P1

Hartree-Fock calculations for the photoionization of heavy atoms and ions in neutron star magnetic fields — Peter Diemand, •Thorsten Kersting, Damir Zajec, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart

Using the method described in the talk by Diemand et al., we determine the photoionization cross section in dipole approximation for heavy atoms and ions in neutron star magnetic field strengths. Continuum states are treated in adiabatic approximation in a self-consistent way. Bound states are calculated by solving the Hartree-Fock-Roothaan equations using finite-element and B-spline techniques. The data are of importance for the quantitative interpretation of observed X-ray spectra that originate from the thermal emission of isolated neutron stars. They can serve as input for modelling neutron star atmospheres with regard to chemical composition, magnetic field strength, temperature and redshift.

A 7.4 Mon 16:00 P1

Correlation function quantum Monte Carlo calculations for ground and excited states of many-electron atoms and ions in neutron star magnetic fields — •Sebastian Boblest, Dirk Meyer, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart

We apply the correlation function quantum Monte Carlo method to the calculation of atomic data of medium-heavy atoms and ions in neutron star magnetic fields. This method allows for the calculation of both ground and excited states, as well as transition rates.

We use basis sets which account for the growing dominance of the cylindrical symmetry as the magnetic field is increased. These basis sets are computed using the Hartree-Fock-Roothaan method.

The atomic data obtained in these calculations are of relevance to the analysis of features discovered in the thermal emission spectra of isolated neutron stars.

A 7.5 Mon 16:00 P1

Recent Improvements in Transport and Application of Hyperpolarized Xe-129 — •Maricel Repetto[1], Mathis Düwel[2], Werner Heil[1], Hans W. Spiess[2], Peter Blümler[1], and Kerstin Münnemann[2] — [1]Johannes Gutenberg University, Institute of Physics, Mainz, Germany. — [2]Max Planck Institute for Polymer Research, Mainz, Germany.

Hyperpolarized (HP) Xe-129 has numerous applications in medicine and fundamental physics. For separating HP Xe-129 from other gases used in the hyperpolarization process, it can be accumulated at 77K. The conditions of this process must be carefully evaluated in order to minimize polarization losses. Different devices and results for this separation process are presented. Additionally, HP Xe-129 must be transported to other sites (e.g. clinics). Therefore, the relaxation time, T1, must be kept as long as possible. Different strategies (e.g. admixing of gases and low-field storage) to achieve this goal are presented together with suitable home-build instrumentation to determine T1. Finally, the application to the patient must be realized in a rapid and biocompatible way. Here we found a very elegant solution by using oxygenation membranes, which dissolve Xe instantaneously and without foaming in any suitable carrier liquid or even blood.

A 7.6 Mon 16:00 P1

Numerical signatures of non-selfadjointness in quantum Hamiltonians — •Matthias Ruf[1], Carsten Müller[1], and Rainer Grobe[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg — [2]Intense Laser Physics Theory Unit and Department of Physics, Illinois State University, Normal, IL 61790-4560 USA

There are quantum mechanical Hamiltonians, which may lose their self-adjointness if certain parameters exceed certain values. For example, it is well known that the Dirac Hamiltonian for the Coulomb potential $V(r) = -Z/r$ loses its essential self-adjointness if the nuclear charge Z exceeds the critical value of $Z_{\rm cr} = 118$ [1].

While non-selfadjoint quantum mechanical operators do not necessarily possess eigenvalues, finite $N \times N$ matrix representations of these, however, may be hermitian and therefore have a finite set of N real eigenvalues. Using the momentum operator, the kinetic energy operator, and the relativistic Hamiltonian of the Coulomb problem for the Klein-Gordon equation as examples, we examine analytically and numerically the properties of the spectrum and eigenvectors in finite dimensional Hilbert spaces. We study the limit of $N \to \infty$ for which some eigenvalues cease to exist as the corresponding operators are not selfadjoint.

[1] B. Thaller, *The Dirac Equation*, Springer (1992)

A 7.7 Mon 16:00 P1

Construction of a Compact ^{3}He Polarizing Facility for Local Usage — •Christian Mrozik, Oliver Endner, Christopher Hauke, Werner Heil, Sergei Karpuk, Jan Klemmer, and Ernst Otten — Johannes Gutenberg-Universität Mainz

Since a decade hyperpolarized ^{3}He, used in fundamental research as well as in medical imaging, is polarized in a central facility, located at the University of Mainz and shipped to the users. The gas is polarized via metastability exchange optical pumping (MEOP) at a pressure of approximately 1 mbar inside a magnetic field of 1 mT. At these parameters the process requires the magnetic field to have a relative gradient of $\Delta B/B < 3.8 \cdot 10^{-4}\,\mathrm{cm}^{-1}$. To construct a compact facility for local gas-polarization it is imperative to create a sufficiently homogeneous magnetic field all over a solenoid's volume in order to be able to use its complete volume for the MEOP assembly. Our concept of a spacious homogenization of a solenoid's magnetic field consists of enclosing it into a shielding of soft magnetic material, providing a high magnetic permeability. In addition to the homogenization of the magnetic field a new concept for the optics, used for the optical pumping has been developed, to fit into the new compact facility. Compared to the currently used facility, a neat linear motor replaces the cumbersome hydraulical drive of the piston, which compresses the gas without polarization-losses from 1 mbar up to 5 bar. The design of the compact apparatus aims to reach a flux of hyperpolarized ^{3}He at $P > 65\%$ of several standard liters per hour.

A 7.8 Mon 16:00 P1

Ultracold long-range giant dipole molecules in crossed electric and magnetic fields — •Markus Kurz[1], Michael Mayle[2], and Peter Schmelcher[1] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]JILA, NIST and University of Colorado, Boulder, Colorado 80309-0440, USA

Giant dipole atoms in crossed electric and magnetic fields have been proven to exhibit extraordinary properties such as a strongly decentered wave function and a huge dipole moment ([1,2]).

Here we explore the existence of ultracold long-range giant dipole molecules by binding a neutral ground state atom to the decentered electronic wave function of the giant dipole atom. It is shown that the adiabatic potential surfaces emerging from the interaction of the ground state atom with the giant dipole electron posses a rich topology depending on the degree of electronic excitation. Binding energies and the vibrational motion in these surfaces are analyzed. Beyond this, we demonstrate the existence of intersection manifolds of excited electronic states potentially to a fast vibrational decay of the ground state atom dynamics [3].

[1] O. Dippel, Phys. Rev. A 49, 4415 (1994)
[2] V. Averbukh, Phys. Rev. A, 59, 3695 (1999)
[3] M. Kurz, in preperation

A 7.9 Mon 16:00 P1

Building mathematical foundations for time-dependent density functional theory — •Markus Penz[1] and Michael Ruggenthaler[2] — [1]Institut für Theoretische Physik, Universität Innsbruck, 6020 Innsbruck, Austria — [2]Department of Physics,

Nanoscience Center, University of Jyväskylä, 40014 Jyväskylä, Finland

In this presentation we study the essential mathematical structures for a rigorous foundation of time-dependent density functional theory, a reformulation of many-body quantum mechanics where the wave function as a fundamental variable is replaced by the electronic density. We introduce a new fixed-point proof of the fundamental one-to-one correspondence between densities and external potentials. Our approach not only sharpens the Theorems of Runge and Gross and van Leeuwen, as no additional time regularity is needed, but also yields interesting restrictions on the density and leads to a problem-adapted set of external potentials.

A 7.10 Mon 16:00 P1

Complex dilation for time-dependent phenomena in driven helium — •Felix Jörder, Pierre Lugan, Vera Neimanns, Klaus Zimmermann, and Andreas Buchleitner — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg i.Br., Deutschland

The electromagnetically driven helium atom defines a paradigmatic scenario of a fragmenting quantum system, characterized by high spectral densities and decay channels into multiple continua. A powerful tool to access the spectral structure underlying the field-induced excitation and fragmentation process is provided by complex dilation of the Hamiltonian, which uncovers the pole structure of the resolvent operator. We summarize the current status of applications of complex dilation techniques in this specific physical context, and discuss novel perspective, such as the impact of the interelectronic repulsion on dynamical localization effects in the excitation process.

A 7.11 Mon 16:00 P1

Strong-field laser atom interaction: dynamic resonances and laser-induced states — •Thomas Keil and Dieter Bauer — Institut für Physik, Universität Rostock, 18051 Rostock, Germany

During the interaction of strong laser fields with atoms, energy levels undergo pronounced nonperturbative AC Stark shifts. It is known, for instance, that Rydberg levels may be brought into multiphoton resonances for particular laser field intensities (Freeman resonances). Such resonances give rise to a nonmonotonic behavior of the ionization rate as a function of the laser intensity. The laser field may also induce bound states that are absent without laser field. If populated, light-induced states are useful for the understanding of unexpected observations such as even harmonics from systems with inversion symmetry. We present photoelectron spectra obtained from the ab initio solution of the time-dependent Schrödinger equation and identify effects of Freeman resonances on them. Light-induced states are investigated via a spectral analysis of the ab initio wavefunction.

A 7.12 Mon 16:00 P1

High-Order Harmonic Generation in the Presence of a Resonance — •Maria Tudorovskaya[1,2] and Manfred Lein[1] — [1]Leibniz Universitaet Hannover, Hannover, Germany — [2]Institut fuer Physik, Universitaet Kassel, Kassel, Germany

High-order harmonic generation is a nonlinear process occuring in the intense laser field affecting on atomic or molecular targets. We investigate high-order harmonic generation from laser-irradiated atoms with a potential that supports a shape resonance. Although the process leads to emittion of photons with very high energy, its effitiency is not very high. Certain harmonics is enhanced due to the presence of the resonance. From the numerical solution of the time-dependent Schroedinger equation, we calculate the harmonic spectra and make time-frequency analysis, revealing the separate contribution of the short and long trajectories as well as the resonance. Using potentials with different shape, we show how parameters of the potential barrier can affect the resonance in the spectrum. We show that significant resonance in the spectrum can be achieved from the pulse length being equal to just a few optical periods of the laser. We simulate the phase matching in a gas medium by coherent summation over intensities. It is shown that the contribution of the long trajectories becomes negligible, but the signature of the resonance is still significant.

A 7.13 Mon 16:00 P1

Engineering the Coherences at the Single-Atom Level — •Andrea Alberti, Michal Karski, Leonid Förster, Andreas Steffen, Noomen Belmechri, Wolfgang Alt, Artur Widera, and Dieter Meschede — Institut für angewandte Physik, Universität Bonn

We demonstrate the capability to coherently steer individual neutral cesium atoms with single lattice-site resolution in a spin-dependent optical lattice. Following the so-called *bottom-up* approach, we engineer a few-body quantum system building it up atom by atom. This has recently enabled us to experimentally investigate 1D quantum walks in real space, which form an ideal model system to investigate transport phenomena dominated by quantum interference. Furthermore, it offers us a direct handle on the boundary between classical and quantum world. The entanglement between internal and external degrees of freedom is increased with the number of steps along the walk. At the moment we preserve quantum coherences over more than 10 steps. We are currently exploring single atom interferometry to get a deeper grasp of the phase evolution of a spatially delocalized atom in a spin-dependent optical lattice.

A 8: Photoionization II

Time: Monday 16:30–18:30 Location: BAR 106

Invited Talk A 8.1 Mon 16:30 BAR 106

Ultrafast Electron and Nuclear Dynamics in Dissociative Ionization of H2/D2 probed by Molecular Frame Photoemission. — •Danielle Dowek — Institut des Sciences Moléculaires d'Orsay, UMR8214, Université Paris-Sud and CNRS, 91405, Orsay, France

Dissociative photoionization of the H2 /D2 molecules, involving resonant excitation of the Q1 and Q2 doubly excited states, provides prototypes for the study of ultrafast electronic and nuclear dynamics. Single photon absorption in the 28-35 eV VUV range induces electronic correlation, coupling between electron and nuclear motion, and intricate interference patterns, taking place on the femtosecond (fs) scale. A state of the art theoretical description of these processes is currently performed, using stationary [1] or time-dependent [2] calculations.

We will discuss DPI of H2 /D2 obtained using the electron-ion vector-correlation (VC) method [3,4] and two excitation modes: the synchrotron radiation SOLEIL, providing linearly and circularly polarized VUV pulses and high-order harmonic generation at CEA-SLIC, where the H21 line was selected using multilayer optics.

The VC method gives access to the molecular frame photoelectron angular distributions (MFPADs) as a function of the Kinetic Energy Release (KER) of the fragments. Ultrafast dynamics including delayed photoemission can be probed at the fs level by comparing measured and computed KER-resolved MFPADs.

[1] F. Martín et al, Science, 315, 629 (2007) [2] J. F. Perez-Torres et al., PRA 80, 011402 (2009) [3] M. Lebech et al., RSI. 73, 1866 (2002) [4] D. Dowek et al, PRL. 104, 233003 (2010)

Invited Talk A 8.2 Mon 17:00 BAR 106

High-resolution soft X-ray spectroscopies of isolated species — Victor Kimberg, Andreas Lindblad, Xiao-Jing Liu, Christophe Nicolas, Emmanuel Robert, Johan Södreström, Oksana Travnikova, and •Catalin Miron — Synchrotron SOLEIL, L'Orme des Merisiers, Saint-Aubin, BP 48, 91192 - Gif-sur-Yvette Cedex, France

Ultra-high resolution X-ray spectroscopies allow probing in great detail femtosecond decay dynamics of inner-shell excited species in both solid state and gas phase. New possibilities have been recently opened owing to bright and highly monochormatic photon beams and state-of-the-art instrumentation available at the newest facilities for dilute matter spectroscopies, such as the PLEIADES beamline in operation since March 2010 at SOLEIL. Doppler types of broadening are nowadays the main limitations of electron spectroscopies at room temperature.

Following the first experimental evidence of Vibrational Scattering Anisotropy (**VSA**) in the resonant Auger decay of core-excited C_2H_2 [Miron *et al.*, PRL 2010], we have recently observed **VSA** in O_2, where the interference between direct photoionization and resonant Auger scattering channels represent the only origin of the **VSA**. We predict **VSA** to be a completely general phenomenon, which is possible to observe as soon as experimental resolution is high enough. The fully variable polarization and high flux at PLEIADES have been also used to study the Auger electron emission anisotropy from dissociating core-excited SF_6 molecules using circularly polarized light, allowing observation of Auger-Doppler profiles [Travnikova *et al.*, PRL 2010].

Invited Talk A 8.3 Mon 17:30 BAR 106

Double Photoionization of Aromatic Hydrocarbons — •Ralf Wehlitz — SRC, UW-Madison, Stoughton, WI-53589, USA

Recently we have studied the double-ionization process in various aromatic hydrocarbons using synchrotron radiation. The double-to-single photoionization ratio was recorded over a large photon energy range in order to compare that ratio for different molecules and atoms. Questions that will be addressed in this talk are: How does the structure of a molecule affect the double photoionization process? Is there an isomer effect? And, how similar is the general photon-energy dependence of the ratio among different hydrocarbons?

Previous investigations on C_{60} [1] showed that the double-to-single photoionization ratio as a function of photon energy can be used to determine geometrical distances of the cluster such as the carbon-carbon distance. Although aromatic hydrocarbons (with benzene being the prototype molecule) do not have localized valence electrons as C_{60} has, we did find a similar effect that leads to an enhanced ratio based on the structure of the benzene ring.

The SRC is supported by US-NSF Grant No. DMR-0537588

[1] P.N. Juranic *et al.*, Phys. Rev. Lett. **96**, 023001 (2006)

A 8.4 Mon 18:00 BAR 106

Are there interference effects of differently localized electrons? — •André Knie, Philipp Reiss, Benjamin Kambs, and Arno Ehresmann — Universität Kassel, Institut für Physik und Center for Interdisciplinary Nanostructure Science and Technology, Heinrich Plett Str. 40, 34132 Kassel, Germany

For many processes occurring in nature quantum mechanical interference causes dramatic counterintuitive observations, requiring detailed understanding of this effect. As a prototypical linear three-atomic molecule N_2O was investigated with almost any known experimental technique. Here we investigate the decay of N 1s-3p resonances of the central N-atom overlapping with resonances of the terminal N-atom. Decays into the N_2O^+ A state will be measured by the N_2O^+ A-X fluorescence. If interference effects are observed, this will be interference of electrons originally localised at different sites.

A 8.5 Mon 18:15 BAR 106

Theory of resonant photoionization of highly charged ions at keV photon energies — •Zoltán Harman[1,2], Marius Schütz[1], Christoph H. Keitel[1], Martin C. Simon[1], José R. Crespo López-Urrutia[1], Christian Beilmann[1], and Joachim Ullrich[1] — [1]Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]ExtreMe Matter Institute EMMI, Planckstrasse 1, 64291 Darmstadt, Germany

Highly charged ions may be further ionized by x-ray radiation, as it happens in, e.g., the warm-hot intergalactic medium. Photoexcitation to an autoionizing state and the subsequent Auger decay gives rise to resonance peaks in photoion or -electron spectra. We calculate cross sections for this process for a variety of ionic systems up to highly charged Fe by means of a fully relativistic distorted wave theory, and compare them to measurements employing an electron beam ion trap and x rays from a synchrotron source (see, e.g., [1]). Understanding photoionization is a prerequisite for the interpretation of a range of astrophysical observations.

[1] M. C. Simon *et al.,* Phys. Rev. Lett. **105**, 183001 (2010).

A 9: Interaction with VUV and X-ray light (FEL) II

Time: Tuesday 10:30–13:00 Location: BAR 205

Invited Talk A 9.1 Tue 10:30 BAR 205

Ultraintense X-Ray Induced Multiple Ionization and Double Core-Hole Production in Molecules — •Nora Berrah[1], Mats Larsson[2], Raymond Feifel[3], Kiyoshi Ueda[4], and Kevin Prince[5] — [1]Western Michigan University — [2]Stokholm University — [3]Uppsala University — [4]Tohoku University — [5]Sincrotron Trieste

We used the world first hard X-ray FEL, the Linac Coherent Light Source (LCLS), to investigate the response of molecular systems to the ultraintense, femtosecond X-ray radiation. We report sequential multiphoton ionization, frustrated absorption and double core hole production mechanisms.

We observed intense X-ray induced ionization and dissociation dynamics leading to various charge states up to fully-stripped fragment ions. By measuring partial ion yields from nitrogen molecules as a function of laser pulse duration ($\sim$ 4 fs - 280 fs), a molecular mechanism of frustrated absorption that suppresses the formation of high charge states at short pulse durations is revealed. Our work will also report on multiple X-ray ionization of molecules and the observation of DCH produced via sequential two-photon absorption on diatomic and triatomic molecules. The production and decay of these states was characterized by using photoelectron spectroscopy and Auger electron spectroscopy.

Invited Talk A 9.2 Tue 11:00 BAR 205

Experiments at SPring-8 FEL: from EUV to X rays — •Kiyoshi Ueda — IMRAM, Tohoku University, Sendai 980-8577, Japan

In 2008, the SPring-8 Compact SASE Source (SCSS) test accelerator, started operation in Japan. It provides linearly polarized EUVFEL pulses in the wavelength region of 51-61 nm. In the last three years, we have been investigating multiphoton processes in atoms, molecules, and clusters irradiated by EUVFEL pulses, using ion and electron momentum spectroscopy and pump-probe techniques. In 2011, SCSS XFEL will start operation. Our scientific program at the XFEL is largely based on research problems which constitute a bridge between atoms and small molecules and more complex systems. We plan to study, for example, light-induced phase transition in nanoclusters and light-induced structural change of single photoreactive biomolecules, using time-resolved coherent X-ray imaging combined with Coulomb-explosion ion imaging and photoelectron diffractions. The talk will describe current status of our EUVFEL experiments as well as plans and preparations for our XFEL experiments.

Invited Talk A 9.3 Tue 11:30 BAR 205

Coupling dependence regarding the Cooper minima positions in two-photon ionization of rare gases — •Markus Braune[1], Toralf Lischke[1], Ande Meissner[1], Markus Ilchen[2], Sascha Deinert[2], Jens Viefhaus[2], Andre Knie[3], and Uwe Becker[1] — [1]Fritz-Haber-Institut, Berlin — [2]DESY, Hamburg — [3]Uni Kassel

Cooper-Minima in partial cross sections in single photoionization are known to arise from the decrease of the overlap integral of the two possible wave functions with different angular momentum of the outgoing electron. Reflections of these intensity variations along photon energy are also exhibit in the angular distribution of photoelectron emission. Such radial effects should actually not show severe deviations for different angular momentum coupling multiplets of the same electron configuration. This is in fact the case for the single-photon ionization of all rare gases. However, open-shell atoms show larger deviations due to so called anisotropic interactions of the outgoing electron and the ionic core in the final state. Very little is known on the strength and behaviour of these anisotropic final state interactions. The second step of sequential two-photon ionization can be regarded as the ionization of an open shell system, namely the singly charged ion of the first ionization step. Hence such interactions are expected to occur. Indeed some recent calculations predict large effects with respect to the higher order anisotropy parameter β_4 showing completely different behaviour in the region of the Cooper minima for the different multiplets. Results of our very recent angle resolved photoelectron spectroscopy measurements are presented.

A 9.4 Tue 12:00 BAR 205

XUV-multiphoton ionization at atomic giant resonances at different timescales — •Nils Gerken, Stephan Klumpp, Vera Linsenmann, Ricarda Laasch, Karolin Mertens, Wilfried Wurth und Michael Martins — Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg, Germany

We present multi-ionization processes of Xenon in the region of the Xe giant resonance measured with ion mass-to-charge spectroscopy at ultrahigh intensities. At the free-electron laser facility FLASH Peak intensities of 10^{12} - 10^{13} W/cm^2 were reached whereas the pulse lengths of a few hundred femtoseconds were longer than in previous Xe^{n+} multiphoton excitations [1,2]. In our experiment we observe strong differences of the relative ion distribution compared to earlier experiments. We concentrate on the mid pulse energy regime, where sequential processes dominate the multiphoton ionization and the resonant structure of the different ions are of importance. Especially Xe^{6+} and Xe^{7+} ion signal intensities are much stronger at pulse lengths in the order of a few hundred femtoseconds compared to previous experiments with one order of magnitude shorter pulse lengths. Furthermore we extended the experiment to other atoms with similar giant resonant excitation behaviour.

[1] A. A. Sorokin et al., Phys. Rev. Lett. 99, 213002 (2007)
[2] M. Richter et al., Phys. Rev. Lett. 102, 163002 (2009)

A 9.5 Tue 12:15 BAR 205

Momentum spectroscopy of ion photo-fragmentation products at XUV energies — •Christian Domesle[1], Hernik B. Pedersen[2], Lutz Lammich[2], Brandon Jordan-Thaden[1], Marko Förstel[3], Tiberiu Arion[3], Uwe Hergenhahn[3], Natalia Guerassimova[4], and Andreas Wolf[1] — [1]Max-Planck Institut für Kernphysik, Heidelberg, Germany — [2]Department of Physics and Astronomy, University of Aarhus, Denmark — [3]Max-Planck Institut für Plasmaphysik, Garching, Germany — [4]HASYLAB at DESY, Hamburg, Germany

Fragmentation of protonated water and small water clusters $H^+(H_2O)_{(n=1,2,3)}$ in the gas phase at XUV energies are of direct relevance in interstellar media and planetary atmospheres. With Free Electron Laser light sources, as FLASH at DESY in Hamburg, investigations of break up processes initiated by ionization of inner valence electrons have become possible. In the crossed beams ion beam infrastructure TIFF at FLASH, the photon and ion beam are temporally and spatially overlapped within a newly designed interaction region. This interaction region, also acting as a saddle point electron spectrometer, allows for trapping the ions and for position and time resolved electron detection. In combination with a serial arrangement of two fragment detectors, charged and neutral fragments can also be time and position analyzed. We report on measurements we performed on protonated water molecules and small clusters, for which fragmentation pathways and branching ratios of the various observed decay channels could be obtained.

A 9.6 Tue 12:30 BAR 205

Laser-based terahertz-feld-driven streak camera for the temporal characterization of fs HHG pulses — •Bernd Schütte, Ulrike Frühling, Marek Wieland, Armin Azima, and Markus Drescher — Universität Hamburg, Hamburg, Germany

We report on a new measurement technique for the temporal characterization of femtosecond (fs) pulses from a high-order harmonic generation (HHG) source. This method is borrowed from attosecond metrology and was first transferred to the fs range at the Free Electron Laser in Hamburg (FLASH) [1]. On a laboratory scale, we now superimpose the 59^{th} order of a HHG source ($\lambda = 13.5\,\mathrm{nm}$) with terahertz (THz) pulses originating from optical rectification in a lithium niobate crystal via the tilted-pulse front method ($\lambda = 250\,\mu\mathrm{m}$) [2]. The generation of HHG and THz radiation with the same laser pulse ensures an inherent synchronization. In contrary to a conventional streak camera, rare gas atoms serve as a photocathode, which are ionized by the HHG pulses. The created electrons are then accelerated by the THz feld, where the momentum gain depends on the THz phase at the ionization time. In this way, the temporal distribution of the HHG pulses is mapped into a distribution of electron energies. By scanning the delay between HHG and THz pulses, the electric feld of the THz pulses could be sampled. In addition, a reconstruction of HHG pulse durations was performed at low photon fluxes where techniques based on nonlinear autocorrelation do not work.

[1] U. Frühling *et al.*, Nature Photonics, Vol. **3**, 523, 2009.
[2] J. Hebling *et al.*, Opt. Express, Vol. **10**, 1161, 2002.

A 9.7 Tue 12:45 BAR 205

Molecular clusters in strong X-ray pulses — •Pierfrancesco Di Cintio, Christian Gnodtke, Ulf Saalmann, and Jan Michael Rost — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Atomic cluster in short and intense laser pulses have received much attention in recent years as they are tunable targets for intense laser-matter interaction. This applies to "conventional" near infrared pulses as well as to VUV and X-ray pulses available from new and upcoming free-electron laser machines. Molecular cluster add another degree of freedom and may thus be a tool to approach the damage processes of large organic molecules as they occur during coherent diffractive imaging with intense X-ray pulses.

Here we present theoretical studies of methane clusters under short X-ray pulses. We observe the segregation of carbon ions and protons in agreement with recent measurements at LCLS by Ditmire et al. [1]. Our microscopic calculations allow for quantitative studies of the proton emission as well as the localization of trapped electrons around the carbon ions which may lead to effective recombination.

[1] T. Ditmire, private communication (2010).

A 10: Ultra-cold atoms, ions and BEC II (with Q)

Time: Tuesday 10:30–12:45 Location: BAR 106

A 10.1 Tue 10:30 BAR 106

Feshbach resonances of harmonically trapped atoms — •Philipp-Immanuel Schneider, Yulian V. Vanne, and Alejandro Saenz — AG Moderne Optik, Humboldt-Universität zu Berlin, Newtonstraße 15, 12489 Berlin

Confined ultracold atoms with their interaction controlled by a magnetic Feshbach resonance (MFR) have vast and intriguing applications e.g. for studying new phases of matter, performing quantum information processing, or simulating condensed matter Hamiltonians. Employing a short-range two-channel description we derive an analytic model of atoms in isotropic and anisotropic harmonic traps at an MFR. On this basis we obtain an analytic expression for the admixture of the resonant bound state and a parameterization of the energy-dependent scattering length which differs from the one previously employed [1]. We validate the model by comparison to full numerical calculations for ^{6}Li-^{87}Rb and explain quantitatively the experimental observation of a resonance shift of trapped gases and of trap-induced molecules in exited bands and band gaps of an optical lattice.

[1] Z. Idziaszek and T. Calarco, Phys.Rev.A **74**, 022712 (2006).
[2] P.-I. Schneider, Y. V. Vanne, and A. Saenz, eprint arXiv:1005.5306

A 10.2 Tue 10:45 BAR 106

an electron-ion crystal in a linear Paul trap — •Weibin Li and Igor Lesanovsky — School of Physics and Astronomy, The University of Nottingham, Nottingham NG7 2RD, UK

Trapping of charged particles has undergone significant advancements in the past decades. Today ions can be controlled with extreme precision in various traps at the quantum level. This has attracted enormous attentions, due to a broad variety of possible applications, for example, in precisions measurements and quantum computation. Traditional ion traps can confine either positively or negatively charged particles while the opposite charge is repelled. We demonstrate that a single electron can be trapped in the centre of a metastable doubly charged ion crystal in a linear Paul trap. A uniform magnetic field is applied in the axial direction, which tightly confines electron in the radial directions, and stabilises the system. At equilibrium, the system is approximated by coupled harmonic oscillators. We discuss the stability properties and the dynamics of the system. Our study illuminates possibilities for coherently manipulating oppositely charged particles simultaneously in linear Paul traps. This has the potential to highlight new perspectives for quantum simulators that use electrons as fundamental constituents and thus are of fundamental interest in condensed matter physics.

A 10.3 Tue 11:00 BAR 106

Influence of reduced dimensionality on ultracold atoms — •Simon Sala[1,2] and Alejandro Saenz[1] — [1]Institut für Physik, Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin — [2]Kirchhoff-Institut für Physik, Ruprecht-Karls Universität Heidelberg, Im Neuenheimer Feld 227, 69120 Heidelberg

Low-dimensional systems of ultracold atoms show unique quantum signatures which are not present in the three dimensional case. Two topical examples in the quasi 1D regime are the fermionization of Bosons, i.e. strongly repulsive Bosons acquire fermionic properties, and the appearance of a confinement-induced resonance (CIR)[1]. Recently both effects were experimentally observed [2,3]. Quasi one-dimensional systems are realized by a tight confinement in two spatial directions freezing out two degrees of freedom. We present a theoretical treatment of two atoms in quasi one-dimensional traps using a full six-dimensional exact diagonalization technique [4]. Coupling effects due to anharmonicity of the trapping potential and the resulting effects on a CIR are investigated. Especially the experimental observed [3] splitting of CIR positions in completely anisotropic traps is an open question we try to answer.

[1] M. Olshanii, Phys. Rev. Lett. **81**, 938 (1998)

[2] B. Paredes et al., Nature **429**, 277 (2004)

[3] Haller et al., Phys. Rev. Lett. **104**, 153202 (2010)

[4] S. Grishkevich, A. Saenz, Phys. Rev. A **80**, 013403 (2009)

A 10.4 Tue 11:15 BAR 106

Single Cs Atoms Interacting with an Ultracold Rb Gas — •Nicolas Spethmann[1], Shincy John[1], Farina Kindermann[1], Amir Moqanaki[1], Claudia Weber[1], Dieter Meschede[1], and Artur Widera[2,1] — [1]Institut für Angewandte Physik, Wegelerstr. 8, 53115 Bonn — [2]Technische Universität Kaiserslautern, Fachbereich Physik, Erwin-Schrödinger-Str., 67663 Kaiserslautern

We immerse single Cs atoms into a many body systems consisting of cold and ultracold Rb gases in order to use the single Cs atom as a sensitive probe for inter-species interaction and as an agent to manipulate the quantum gas.

In order to study ground state collisions between a single Cs atom and a quantum degenerate Rb gas we have developed techniques to combine a quantum gas with a single trapped neutral atom. For this purpose, an optically trapped Rb BEC is prepared in the magnetic field insensitive $F = 1$, $m_F = 0$ state. Then single Cs atoms are loaded into a superimposed 1D-lattice, which exerts a strong potential for Cs atoms and a weak potential for Rb. At ultralow temperatures and with negligible scattering of photons, ground state collions between the single atom and the quantum gas determine the interaction. This enables (coherent) probing and manipulation of the BEC by the single atom. We will report on the ground state interactions between single Cs atoms and a quantum gas and our recent progress controlling the single atom inside the quantum gas.

A 10.5 Tue 11:30 BAR 106

Probing an ultracold atomic crystal with matter waves — Bryce Gadway, Daniel Pertot, Jeremy Reeves, and •Dominik Schneble — Department of Physics & Astronomy, Stony Brook University, Stony Brook, NY 11794, USA

We explore the scattering of matter waves from ultracold atoms held in an optical lattice. By “shining” a one-dimensional Bose gas onto an atomic Mott insulator (target), we observe Bragg diffraction peaks that reveal the target’s crystalline structure. We find a systematic dependence of the Bragg intensity on the degree of atom localization, and recover a transition to coherent momentum and energy exchange (“Newton’s cradle”) in the limit of free target atoms. Neutral-atom diffraction can serve as a novel experimental technique for probing atomic many-body systems.

A 10.6 Tue 11:45 BAR 106

Correlated phases of bosons in tilted, frustrated lattices — •Susanne Pielawa, Takuya Kitagawa, Erez Berg, and Subir Sachdev — Physics Department, Harvard University, Cambridge, MA 02138, USA

The search for correlated quantum phases of cold atoms in optical lattices has focused mainly on entangling the spin degrees of freedom on different lattice sites. We show that there are also rich possibilities for correlated phases in the density sector, and these are likely to be readily accessible by tilting Mott insulators into metastable states. It has been previously shown that a Mott insulator in a potential gradient undergoes an Ising quantum phase transition when the potential drop per lattice spacing is close to the repulsive interaction energy [1]. Here we theoretically study bosons in tilted, frustrated, two-dimensional lattices. The phases we find include phases with charge density order, a sliding Luttinger liquid phase, and a liquid-like ground state with no broken lattice symmetry.

[1] S. Sachdev, K. Sengupta, and S. M. Girvin, Phys. Rev. B 66, 075128 (2002).

A 10.7 Tue 12:00 BAR 106

Injection locking of a trapped-ion phonon laser - the detection of ultraweak forces — •Sebastian Knünz[1], Maximilian Herrmann[1], Valentin Batteiger[1], Guido Saathoff[1], Kerry Vahala[2], Theodor W. Hänsch[1], and Thomas Udem[1] — [1]MPQ, Garching, Germany — [2]Caltec, Pasadena, USA

A single trapped ion, addressed by both a red-detuned cooling laser and a blue-detuned pump laser can exhibit stable oscillatory motion with a well defined threshold. We have shown that this oscillation is the result of stimulated emission of center-of-mass phonons, providing saturable amplification of the motion. We show that the dynamics of this "phonon laser" are surprisingly sensitive to external fields; we demonstrate phase synchronization ("injection locking") to an external signal by applying forces as weak as 5 yN (yocto=10^{-24}). This enormous sensitivity might allow the detection of the nuclear spin of a single atom or molecule.

A 10.8 Tue 12:15 BAR 106

Nucleation of solitons in a quasi-1D Bose-Einstein condensate: the Kibble-Zurek mechanism — •Gor Nikoghosyan, Adolfo del Campo, Alex Retzker, and Martin Plenio — Institut für Theoretische Physik, Albert-Einstein Allee 11, Universität Ulm, D-89069 Ulm

Finite-rate cooling of a quasi-1D thermal atomic cloud leads to the spontaneous nucleation of solitons during Bose-Einstein condensation (BEC). We study whether the dynamics of the transition can be described in terms of equilibrium properties using the Kibble-Zurek mechanism (KZM), and simulate the process within the stochastic Gross-Pitaevskii equation. We propose a novel method to detect the density of solitons in a quasi-1D BEC. This method is based on the measurement of the second order correlation function which enables the detection of solitons without knowing their location. The dependence of the density of solitons on the cooling rate of the atomic cloud for realistic experimental conditions is numerically analyzed, and agrees with the KZM only when this is extended to account for the inhomogeneous nature of the condensation arising from the external trapping potential.

A 10.9 Tue 12:30 BAR 106

Propagation of a wave-packet in a nonlinear and disordered medium in two dimensions — •Georg Schwiete[1] and Alexander Finkelstein[2] — [1]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, Germany — [2]Texas A&M University, College Station, USA

We develop an effective theory of wave-packet propagation in a nonlinear and disordered medium. The theory is formulated in terms of a nonlinear diffusion equation. Despite its apparent simplicity this equation describes novel phenomena which we refer to as "locked explosion" and "diffusive" collapse. The equation can be applied to such distinct physical systems as laser beams propagating in disordered photonic crystals or Bose-Einstein condensates expanding in a disordered environment.

A 11: Precision spectroscopy of atoms and ions III

Time: Tuesday 14:00–15:30 Location: BAR 205

A 11.1 Tue 14:00 BAR 205

Toroidale supraleitende Resonatoren hoher Güte zum Nachweis einzelner geladener Protonen — •Andreas Mooser[1,2], Klaus Blaum[3,4], Holger Kracke[1,2], Wolfgang Quint[5], Cricia Rodegheri[1], Stefan Ulmer[1,2,5] und Jochen Walz[1,2] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz — [2]Helmholtz-Institut Mainz, 55099 Mainz — [3]Max-Planck-Institut für Kernphysik, 69117 Heidelberg — [4]Ruprecht-Karls-Universität, 69047 Heidelberg — [5]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt

Ziel des Experiments ist die erste direkte Messung des g-Faktors eines einzelnen Protons in einer Penningfalle. Der g-Faktor kann hierbei aus der Zyklotronfrequenz und der Larmorfrequenz bestimmt werden. Zur Messung der Frequenzen werden hochempfindliche Detektoren, die den Nachweis eines einzelnen Protons erlauben, benötigt. Das Signal kann über induzierte Ströme mit Detektoren, bestehend aus Resonatoren hoher Güte und einer nachfolgenden rauscharmen Verstärkerstufe, nachgewiesen werden. Mit einem ersten toroidalen Resonator wurde eine freie Güte von 148000 bei einer Frequenz von 1,6 MHz erreicht. Auf die Verlustmechanismen, welche entscheidend zur Entwicklung der Resonatoren beitragen, wird eingegangen. Zusammen mit der kryogen betrieben Verstärkerstufe konnte ein Signal/Rausch-Verhältnis von 31 dB erreicht werden.

A 11.2 Tue 14:15 BAR 205

Production of Antihydrogen via Double Charge Exchange — •Andreas Müllers — for the ATRAP collaboration — Johannes Gutenberg Universität Mainz, Institut für Physik 55099 Mainz

The comparison of the $1S-2S$ transition in hydrogen and antihydrogen will provide an accurate test of CPT-symmetry. Antiprotons and positrons are readily stored and cooled in the same Penning trap, but separated by a potential barrier. Three body recombination, the standard method to produce antihydrogen, requires driving the particles to overcome this barrier, and therefore heating them. Since the typical depths of neutral atom traps are on the order of 0.5 K, confinement of single antihydrogen atoms produced this way has only recently been demonstrated [1]. For precision spectroscopy, a larger number of cold antihydrogen is advantageous. To this purpose, the ATRAP-collaboration is also investigating a different production scheme: Cesium is laser-excited to Rydberg states and collides with positrons, forming positronium atoms in a charge exchange reaction. These are no longer bound by the electric fields of the Penning trap and interact with antiprotons, producing antihydrogen in a second charge exchange. We developed the techniques to laser-excite Cesium atoms to high-n states within the strong magnetic fields of our Penning- and neutral-atom Ioffe-trap. Also, production of positronium atoms is reported and the first trials to trap antihydrogen made by this method were performed.

[1] doi:10.1038/nature09610

A 11.3 Tue 14:30 BAR 205

High resolution atom gyroscope — •Peter Berg, Sven Abend, Christian Schubert, Michael Gilowski, Wolfgang Ertmer, and Ernst Rasel — Institut für Quantenoptik, Universität Hannover

Atomic quantum sensors are a key-technology for the ultra-precise monitoring of accelerations and rotations, which make them an ideal tool for applications in fundamental physics and metrology. In the reasearch project CASI (Cold Atom Sagnac Interferometer) an atomic gyroscope based on matter-wave interferometry is realized to measure rotations and accelerations. In order to distinguish between them, the apparatus uses two counterpropagating interferometers in a differential measurement scheme. The atomic ensembles are launched simultaneously in a pulsed mode onto flat parabolas with a forward drift velocity of $2,79$ m/s. In three spatially separated interaction zones coherent beam splitting processes are realized by using Raman transitions. In this way, various interferometer configurations enclosing areas of several mm^2 can be tested. In this talk we discuss the influence of the main noise sources which currently limit the sensitivity of our atomic gyroscope to a few 10^{-7} rad/s. In this context, the latest interferometric measurements and future improvements of the sensor based on the provided analysis will be presented. This work is supported by the DFG, QUEST, and IQS.

A 11.4 Tue 14:45 BAR 205

Einzelnes hoch geladenes Ion in einer Penning-Falle als Probe für eine zeitliche Variation der Feinstrukturkonstanten — •Wolfgang Quint[1,2], Manuel Vogel[1] und Victor Flambaum[3] — [1]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [2]Ruprecht-Karls-Universität Heidelberg — [3]University of New South Wales, Sydney, Australien

Eine mögliche Zeitabhängigkeit der fundamentalen Wechselwirkungen der Physik wurde erstmals von Dirac diskutiert und in einen Zusammenhang mit der Expansion des Universums gestellt. Ein experimenteller Nachweis einer solchen zeitlichen Änderung würde einen wichtigen Beitrag zur Vereinheitlichung der elektroschwachen und starken Wechselwirkungen einerseits und der Einsteinschen Allgemeinen Relativitätstheorie andererseits liefern. Eine umfassende Beschreibung aller physikalischen Wechselwirkungen in einer vereinheitlichten Theorie ist eine der offenen Kernfragen der Physik. Ziel des hier vorgestellten Projekts ist die Bestimmung der Variation fundamentaler Konstanten durch eine Messung der Energie optischer Übergänge in hoch geladenen Ionen unter Einsatz einer neuartigen Spektroskopiemethode [1], bei der einzelnes hoch geladenes Ion in einer Penning-Ionenfalle gespeichert und gekühlt wird. Unser Interesse gilt hoch geladenen Ionen, in denen kürzlich optische Übergänge vorhergesagt wurden, die um bis zu drei Größenordnungen sensitiver auf eine Variation fundamentaler Größen sind als alle bisher betrachteten atomaren Systeme [2]. [1] M. Vogel and W. Quint, Phys. Rep. 490, 1 (2010). [2] J.C. Berengut, V.A. Dzuba und V.V. Flambaum, Phys. Rev. Lett. 105, 120801 (2010).

A 11.5 Tue 15:00 BAR 205

The Size of the Proton from Muonic Hydrogen — •Tobias Nebel and for the CREMA-collaboration — Max–Planck–Institut für Quantenoptik, Garching, Germany.

The charge radius R_p of the proton has so far been known with a precision of about 1% from both electron scattering and precision spectroscopy of hydrogen.

We have recently determined R_p by means of laser spectroscopy of the exotic "muonic hydrogen" atom [1]. Here, the muon, which is the 200 times heavier cousin of the electron, orbits the proton with a 200 times smaller Bohr radius. This enhances the sensitivity to the proton's finite size tremendously.

Our new value $R_p = 0.84184\,(67)$ fm is ten times more precise than the generally accepted CODATA value, but it differs by 5 standard deviations from it. A lively discussion about possible solutions to the "proton size puzzle" has started.

[1] R. Pohl et al., "The size of the proton", Nature 466, 213 (July 2010)

A 11.6 Tue 15:15 BAR 205

Quantum correlations in the two-photon decay of few-electron ions — •Filippo Fratini[1,2], Malte Tichy[3], Thorsten Jahrsetz[1,2], Andreas Buchleitner[3], Stephan Fritzsche[2,4], and Andrey Surzhykov[1,2] — [1]Physikalisches Institut, Heidelberg University, Heidelberg, Germany — [2]GSI, Darmstadt, Germany — [3]Physikalisches Institut, Freiburg University, Freiburg, Germany — [4]Frankfurt Institute for Advanced Studies, Frankfurt, Germany

We present a theoretical study of the entanglement of the photon pair emitted in the decay of metastable states in hydrogen–like and helium–like ions. By using non–relativistic dipole approximation, we are able to derive analytical expressions for the (degree of) entanglement which give intuitive insights on the quantum correlation of the two emitted photons. In addition, by comparing these non–relativistic results with predictions given by the relativistic theory, we investigate relativistic and higher, non–dipole effects on the photons' polarization states. Detailed calculations are shown for the two–photon $2s_{1/2} \rightarrow 1s_{1/2}$ transition in hydrogen–like ions as well as for the $1s_{1/2}2s_{1/2}\,{}^1S_0 \rightarrow 1s_{1/2}1s_{1/2}\,{}^1S_0$, $1s_{1/2}2s_{1/2}\,{}^3S_1 \rightarrow 1s_{1/2}1s_{1/2}\,{}^1S_0$ and $1s_{1/2}2p_{1/2}\,{}^3P_0 \rightarrow 1s_{1/2}1s_{1/2}\,{}^1S_0$ transitions in helium–like ions.

A 12: Interaction of matter with ions I

Time: Tuesday 14:00–15:30 Location: BAR 106

Invited Talk A 12.1 Tue 14:00 BAR 106

Dissociative charge transfer into molecular ions — •Lothar Ph. H. Schmidt, Reinhard Dörner, and Horst Schmidt-Böcking — Institut für Kernphysik, Goethe-Universität Frankfurt am Main

The dissociative electron transfer from He into slow hydrogen molecular ions was measured in a kinematically complete experiment by using cold target recoil ion momentum spectroscopy (COLTRIMS) in combination with a molecular fragment imaging technique. Neutral molecules produced by electron capture into an excited electronic state dissociate in a second step of the reaction.

We were able to determine the initial vibration energy from the measured momenta. The vibrationally excited states yield a multi peak structure in the measured kinetic energy releases (KER) distribution. We used several models as the reflection approximation to reconstruct the square of the initial nuclear wave functions.

In case of close collisions between the molecule and the helium atom we find a striking two center interference pattern in the He transverse momentum distribution. From that - just as for the case of an optical double slit experiment - we can infer the distance between the scattering centers. We observed a correlation between the interference pattern and the selected KER as expected from the reflection approximation.

Using HD^+ labels the molecular scattering centers by the isotope mass. This does not lead to a loss of interference fringe contrast, but modifies the interference pattern which can be explained by a breakdown of the axial recoil approximation.

A 12.2 Tue 14:30 BAR 106

Manipulating Atomic Fragmentation Processes by Controlling the Projectile Coherence — Kisra Egodapitiya[1,2], •Aaron LaForge[1,2], Sachin Sharma[1], Ahmad Hasan[3], Robert Moshammer[2], Daniel Fischer[2], Don Madison[1], and Michael Schulz[1] — [1]Dept. of Physics, Missouri University of Science & Technology , Rolla, USA — [2]Max Planck Institut für Kernphysik, Heidelberg, DE — [3]Dept of Physics, United Arab Emirates University, Abu Dhabi, UAE

We have performed an atomic collision version of Young*s double slit experiment. The scattering angle dependence of double differential cross sections for ionization of H2 by 75 keV proton impact for a fixed projectile energy loss was studied. Depending on the coherence of the projectile beam, an interference due to indistinguishable diffraction of the projectile from the two atomic centers was either present or absent in the data. The results have far-reaching implications on several decades of atomic scattering theory.

A 12.3 Tue 14:45 BAR 106

Das PRIOC-Experiment: Präzisionsexperimente in Atom-Ionen-Stössen — •Renate Hubele, Dominik Globig, Aditya Kelkar, Aaron LaForge, Katharina Schneider, Martin Sell, Xincheng Wang und Daniel Fischer — Max-Planck Institut für Kernphysik, Heidelberg

Zur detaillierten Untersuchung der korrelierten Mehrteilchendynamik in Ion-Atom-Stössen wird am MPIK gerade ein Experiment entwickelt, bei welchem erstmals drei unterschiedliche Techniken kombiniert werden sollen. Diese Kombination aus einem elektronengekühlten Ionenstrahl in einem Speicherring, einem Reaktionsmikroskop zur kinematisch vollständigen Untersuchung von Fragmentationsprozessen und dem ultrakalten Lithium-Target einer magneto-optischen Falle wird es in Zukunft ermöglichen, die Dynamik z.B. in Ionisationsprozessen mit einer bisher unerreichten Auflösung zu untersuchen. Die experimentelle Herausforderung bei MOT-REMI-Experimenten - also der Verbindung aus einem Reaktionsmikroskop mit einer Magneto-Optischen Atomfalle - besteht insbesondere bei der Detektion niederenergetischer Elektronen darin, dass das magnetische Quadrupolfeldes der MOT mit dem homogenen Magnetfeld des Reaktionsmikroskopes nicht vereinbar ist, bzw. dass diese Felder daher äusserst schnell geschaltet werden müssen. Der Aufbau und erste Testmessungen mit dem neuen Spektrometer werden vorgestellt.

A 12.4 Tue 15:00 BAR 106

Two-electron transfer in collisions of highly charged ions with ultracold Na atoms — •Ina Blank[1], Corine Meinema[1], Ronnie Hoekstra[1], Simone Götz[2], Bastian Höltkemeier[2], and Matthias Weidemüller[2] — [1]KVI, Atomic and Molecular Physics, Zernikelaan 25, NL-9747 AA Groningen, the Netherlands — [2]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, D-69120 Heidelberg, Germany

The process of two-electron transfer in collisions of ions with atoms is an example of many-particle dynamics of a Coulomb system. We have investigated two-electron transfer in collisions of O^{6+} with Na(3s). The electron transfer is studied by precisely measuring the momentum of the recoils ions. The target is provided by a magneto-optical trap. Two different reaction mechanisms are observed: Final states O^{4+}(3ln'l') with n'≥5 are created by sequential electron transfer, while the two electrons captured into the O^{4+}(3l3l') states are transferred simultaneously. Energy dependent measurements reveal an increase of the simultaneous electron transfer with decreasing energy.

A 12.5 Tue 15:15 BAR 106

Energy loss and charge-transfer of heavy ions in laser-generated plasma — Alexander Frank[1], A. Blazevic[2], M. Basko[3], P. L. Grande[4], •M. Börner[1], W. Cayzac[1], T. Hessling[2], G Schiwietz[5], D. Schumacher[1], An. Tauschwitz[6], and M. Roth[1] — [1]TU Darmstadt — [2]GSI Darmstadt — [3]ITEP, Moscow — [4]Universidade Federal do Rio Grande do Sul, Brazil — [5]Helmholtz-Zentrum Berlin — [6]Universität Frankfurt

At GSI the plasma physics group is investigating the differences in the interaction processes of swift heavy ions penetrating either cold matter or hot and dense laser-generated plasma. The plasma target is created by direct laser irradiation of a target foil. This scheme produces high temperatures and hence high ionization degrees. A new spectrometer based on CVD diamond was developed for measuring the projectile charge state distribution exiting the target and energy loss at the same time. The experiments carried out on very thin carbon foils resulted in cross sections for the charge transfer processes. These cross sections were recalculated for plasma conditions. The combination of the projectile charge states in plasma and the corresponding stopping power calculated by a modified version of the CasP code allows to reproduce the measured energy losses and charge distributions and consequently to explain the differences between hot and cold matter. A special focus in the theoretical description is laid upon modeling the relevant charge transfer and energy loss processes and not relying on an effective charge description which will be presented in this talk.

A 13: Poster II

Time: Tuesday 18:00–20:00 Location: P1

A 13.1 Tue 18:00 P1

Diffraction patterns of ensembles of small molecules — •Martin Winter, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik koplexer Systeme

Upcomming X-ray free-electron lasers produce radiation with a high brilliance at Angstrom wavelengths. These sources can image molecules with a resolution down to the atomic scale. However, since the cross sections of the interaction are small, the resulting diffraction patterns will be very faint. The retrieval of the molecular structure out of many faint diffraction images is very challenging [1].

Therefore we propose a new method to determine the structure of small molecules from their diffraction patterns. From their incoherent sum, all intra-molecular distances and their multiplicities are extracted. This leads to a multidimensional turnpike problem which we tackle by two different methods: a backtracking strategy proposed by Skiena et al. [2] and a variation of the satisfiability problem using multidimensional scaling.

[1] K.J. Gaffney and H.N. Chapman, Science 316, 1444 (2007).
[2] S. Skiena, W. Smith and P. Lemke, Proceeding SCG, doi:10.1145/98524.98598

A 13.2 Tue 18:00 P1

Collapse and Revival and Trap-induced Dynamics in Bosonic Lattice Systems — •Michael Buchhold[1], Ulf Bissbort[1], Sebastian Will[2,3], and Walter Hofstetter[1] — [1]Institut für Theoretische Physik, Johann Wolfgang Goethe-Universität, 60438 Frankfurt/Main — [2]Fakultät für Physik, Ludwig-Maximilians-Universität, 80799 München — [3]Max-Planck-Institut für Quantenoptik, 85748 Garching

The recently achieved long-time observation of collapse and revival dynamics of a Bose-Einstein condensate loaded into a three-dimensional optical lattice allows to directly reveal the presence of effective coherent multi-particle interactions, generated via transitions to higher lattice orbitals.

To theoretically describe the collapse and revival dynamics of a BEC in an inhomogenous optical lattice, an effective single-band Hamiltonian in the Gutzwiller approximation is used, which includes transitions to higher bands by the use of renormalized parameters.

We study the interplay between quantum dynamics induced by the presence of a confining trap potential and the collapse and revival dynamics. We demonstrate that, with high accuracy, the dynamics in a ramped-up lattice can be described within a single particle picture, although inter-site tunneling is almost completely suppressed.

A 13.3 Tue 18:00 P1

Chromium Bose-Einstein condensates in multi-well potentials — •Juliette Billy, Stefan Müller, Emanuel Henn, Holger Kadau, Philipp Weinmann, David Peter, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart

To probe the long-range anisotropic dipolar interaction (DI) in chromium Bose-Einstein condensates (BECs), we aim to extend the geometry-dependent stability diagram of dipolar BECs [1] to highly oblate traps. Experimentally we slice a condensate into several pancake shaped clouds using a 1D optical lattice and investigate the stability of the system, comparing it to theoretical calculations. Our results support significant coupling between neighboring layers through the DI. For further investigating this coupling, we plan a second experiment to study the minimal system consisting of a dipolar BEC trapped in a triple-well potential [2]. The experimental realization of such a system implies major upgrades of our apparatus, which we detail here.

[1] T. Koch *et al.*, Nature Physics **4**, 218 (2008)
[2] T. Lahaye *et al.*, Phys. Rev. Lett. **104**, 170404 (2010)

A 13.4 Tue 18:00 P1

Theory of a dipolar quantum gas in a multi-well potential — •David Peter[1], Krzysztof Pawłowski[2], Kazimierz Rzazewski[2], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart — [2]Center for Theoretical Physics, Polish Academy of Sciences, Warsaw

We investigate the physics of dipolar bosons in a multi-well potential, generalizing what has been done for the triple-well system in [1]. Due to the non-local character of the dipolar interaction and the finite size of the system, inter-site effects are crucial and lead to a large variety of ground states – some of them not being apparent in the triple-well system. These calculations are also applicable to the situation where a dipolar Bose-Einstein condensate is loaded into a 1D optical lattice with a large number of sites occupied.

[1] T. Lahaye *et al.*, Phys. Rev. Lett. **104**, 170404 (2010)

A 13.5 Tue 18:00 P1

Self-organized phase of strongly interacting Bose gases in an optical cavity — •Yongqiang Li, Liang He, and Walter Hofstetter — Johann Wolfgang Goethe Universität Frankfurt (Main)

Motivated by a recent experiment on the BEC-cavity system [1] in which a self-organization phase transition was realized in an open system formed by a Bose-Einstein condensate coupled to an optical cavity, we numerically simulate an ultracold Bose gas in a high-finesse optical cavity by means of real-space Bosonic Dynamical Mean Field Theory [2]. We observe the phase transition from a normal to a self-organized phase and investigate the influence of superfluidity and thermal fluctuations on the self-organized phase in an optical cavity without a harmonic trap. In the presence of a harmonic trap, the coexistence of superfluid, mott-insulating and self-organized phase is observed. We find that the appearance of the wedding-cake density distribution of strongly-interacting Bose gases plays an important role on the buildup of the self-organized phase.

[1] K. Baumann, C. Guerlin, F. Brennecke and T. Esslinger, Nature **464**, 1301 (2010).
[2] Y. Li, L. He, W. Hofstetter, in preparation.

A 13.6 Tue 18:00 P1

Entropy role on the size of an atomic Fermi gas in an optical lattice — •M.Reza Bakhtiari[1], Bernd Schmidt[1], Irakli Titvinidze[1], Michiel Snoek[2], Ulrich Schneider[3], and Walter Hofstetter[1] — [1]Institut für Theoretische Physik, Johann Wolfgang Goethe–Universität, 60438 Frankfurt/Main, Germany — [2]Institute for Theoretical Physics, Valckenierstraat 65, 1018 XE Amsterdam, The Netherland — [3]Fakultät für Physik, Ludwig-Maximilians-Universität, 80799 München, Germany

We theoretically investigate the thermodynamic properties of an inhomogeneous Fermi gas in a 3D optical lattice. We study the interplay between the strong correlation effects and the entropy of the trapped gas. Upon increasing the attractive interaction, this interplay leads to an anomalous expansion in size of the atomic cloud. We model the system by an inhomogeneous Fermi-Hubbard model and we apply a Dynamical Mean-Field Theory (DMFT) combined with a Local Density Approximation to compute the atomic density, superfluid order parameter, entropy and the atomic cloud size. Whenever applicable, we also compare DMFT findings with the result of a high-temperature expansion. Our results show a good agreement with the experiment [1] in which the anomalous expansion of a trapped Fermi gas was observed.

[1] L. Hackermüller *et al.*, Science **327**, 1621 (2010).

A 13.7 Tue 18:00 P1

Matter wave guiding through a photonic bandgap fiber — •Hannes Duncker, André Wenzlawski, Lars Wacker, Patrick Windpassinger, and Klaus Sengstock — Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

In this contribution, we present a project where we intend to study light-matter interaction in an extremely one-dimensional geometry. Ultracold atoms are loaded into a hollow core photonic bandgap (HCPBG) fiber. As a first step, we have been able to demonstrate guiding of cold, slow atoms through an 88 mm long piece of fiber [1]. The guiding potential is created by a far-off resonance dipole trap which propagates in the hollow core of the HCPBG fiber. By imaging the guided atoms' fluorescence signal, we observe a peak atomic flux of 1.2×10^5 atoms/s. Combined with new cooling techniques, single mode operation of the waveguide should be achievable which would pave the way towards guided matter wave interferometry. Furthermore, the tight confinement allows for strong light-atom coupling in a well defined optical potential over macroscopic distances.

[1] S. Vorrath et al, NJP (in press, 2010), Preprint arXiv:1010.0101

A 13.8 Tue 18:00 P1

Experiments with ultracold atomic mixtures in optical lattices — •Daniel Pertot[1], Bryce Gadway[1], Jeremy Reeves[1], Rene Reimann[1,2], and Dominik Schneble[1] — [1]Department of Physics & Astronomy, Stony Brook University, Stony Brook, NY 11794, USA — [2]Present address: Institut für Angewandte Physik, Universität Bonn, 53115 Bonn, Germany

Quantum gases in optical lattices allow for fundamental studies in atomic and condensed-matter physics. We have performed several experiments with binary homonuclear atomic mixtures (derived from a Bose-Einstein condensate) in lattices whose depth can be independently controlled for each component. Interactions in the mixture lead to novel features: collinear atomic four-wave mixing [1], polaronic effects in the strongly correlated regime [2], and scattering from crystalline atomic structures.

[1] D. Pertot et al., Phys. Rev. Lett. 104, 200402 (2010) [2] B. Gadway et al., Phys. Rev. Lett. 105, 045303 (2010)

A 13.9 Tue 18:00 P1

Pair Correlations in Low-Dimensional Ultracold Quantum Gases — •Arne Ewerbeck, Matthias Scholl, Andreas Vogler, Peter Würtz, Vera Guarrera, Giovanni Barontini, and Herwig Ott — Fachbereich Physik, Technische Universität Kaiserslautern

We present an experimental approach for in-situ correlation measurements in ultracold gases. In our experiment we ionize atoms of an atomic ensemble by electron impact ionization, using a tightly focussed electron beam. The ions are extracted by means of electrostatic optics and subsequently detected. This allows us to probe density distributions with high spatial resolution. Furthermore, by analyzing the temporal sequence of ion signals, we aim to determine the pair correlation function of trapped one- and twodimensional quantum gases. A combination of optical dipole-traps is used to confine the atoms in a low-dimensional geometry. The current status of the experiment is presented.

A 13.10 Tue 18:00 P1

Preparation and characterization of cold fermionic gases in optical lattices — •Daniel Greif, Thomas Uehlinger, Leticia Tarruell, Gregor Jotzu, and Tilman Esslinger — Institute for Quantum Electronics, ETH Zurich, Switzerland

Ultracold atoms in optical lattices are an almost ideal realization of the celebrated Hubbard Hamiltonian, which is a central model in strongly correlated condensed matter systems. The recent advance in control of fermionic quantum gases makes these systems a promising candidate to study the low temperature regime. This requires both development of sensitive probes on magnetic correlations and novel schemes for preparation of low entropy states in the lattice. We report on measurements of nearest-neighbor correlations, which can be used to detect local spin ordering, and recent progress on preparation of cold fermionic gases in the lattice.

A 13.11 Tue 18:00 P1

Contolling a bond with light: Ultralong-range Rydberg molecules — •Johannes Nipper, Björn Butscher, Jonathan Balewski, Robert Löw, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Germany

We report on experiments exploring ultralong-range Rydberg molecules. These unusual bound states between Rydberg atoms and ground state atoms feature novel binding mechanisms based on low energy electron scattering as well as internal quantum reflection at a shape resonance of electron-atom scattering [1].

Besides the binding energies of dimer and trimer states, further properties are studied in high resolution spectra in the high density regime. This extends from density dependend lifetime measurements to experiments in electric fields that reveal a molecular Stark effect due to a permanent electric dipole moment of the molecules.

The possibility to coherently control this binding mechanism is shown in Rotary echo and Ramsey experiments and the coherence times are extracted [2].

[1] V.Bendkowsky et.al., PRL 105, 16 (2010)
[2] B.Butscher et.al., Nature Physics, nphys1828 (2010)

A 13.12 Tue 18:00 P1

Many body physics using Strontium lattice — •Rick Mukherjee[1], James Millen[2], Matthew Jones[2], and Thomas Pohl[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Department of Physics, Durham University, United Kingdom

We explore prospects for optical lattice confinement of Strontium Rydberg atoms. In particular we identify a magic frequency in the bluedetuned spectrum which allows for simultaneous trapping of ground and Rydberg states and show that the overall lifetime of such systems is only limited by spontaneous decay. Further, it is found that the Strontium nS states feature attractive van der Waals interactions, which is used to devise a scheme for the robust generation of manybody Schroedinger cat states. The latter exemplifies the potential of the described approach for quantum information schemes and metrology by exploiting the extreme interactions between Rydberg atoms.

A 13.13 Tue 18:00 P1

Ultracold Rydberg Molecules — •Iris Reichenbach[1], Weibin Li[2], and Jan-Michael Rost[1] — [1]Max Planck Institut für Physik komplexer Systeme, Dresden, Germany — [2]University of Nottingham, Nottingham, UK

Recently, there has been considerable interest in Rydberg molecules, that is molecules involving one Rydberg atom and a ground state atom or molecule. [1,2,3] This is due to the large size, high polarizability and low binding energy of such molecules, which allow for control of the resulting states and interactions. Furthermore, the unique properties of these molecules allows for basic research in ultracold chemistry, as well as a more detailed examination of ultracold scattering processes, ultracold gases and possible applications in quantum information processing. We focus here on a molecule consisting of one Rydberg atom and one ground state dimer, and examine the dependence of the resulting state on the details of the constituents, such as their relative orientation.

[1] C. H. Greene et al, PRL 85, 2458 (2000).
[2] V. Bendkowsky et al, Nature (London) 458, 1005 (2009).
[3] V. Bendkowsky et al. PRL 105, 163201 (2010).

A 13.14 Tue 18:00 P1

Spectral properties of finite, laser-driven lattices of ultracold Rydberg atoms — •Wolfgang Zeller[2], Nikolas Tezak[1,2], Michael Mayle[3], and Peter Schmelcher[2] — [1]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg, Germany — [2]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]JILA, NIST and University of Colorado, Boulder, Colorado 80309-0440, USA

We investigate the spectral properties of a finite lattice of coherently excited Rydberg atoms in the frozen Rydberg gas regime. Both uniform as well as multiply-spaced one-dimensional lattices are studied.

In the case of a weak laser coupling we give a comprehensive description for the excitation patterns and degeneracies. We find a multitude of Rydberg states with well-defined excitation properties which are adiabatically accessible starting from the ground state. The precise analysis and knowledge of the spectral features suggest a method to experimentally probe the strong and long-ranged mutual interaction of Rydberg atoms.

In the strong laser regime, the system can be approximated with analytical solutions by performing site-specific rotations and introducing fermionic ladder operators.

Patterned lattices allow us to design certain ground state crossovers involving different Rydberg excitation patterns.

A 14: Interaction with VUV and X-ray light III

Time: Friday 10:30–12:45 Location: BAR 106

Invited Talk A 14.1 Fri 10:30 BAR 106

Synchrotron radiation spectroscopy of ions — •Alfred Müller — Institut für Atom- und Molekülphysik, Universität Giessen, Germany

Photoionization and -fragmentation of ions is studied by exposing suitable ionic targets to synchrotron radiation. The most common scenario for cross section measurements is the photon-ion merged-beam technique. Conventional mass and charge state analysis of accelerated ions provides well defined, clean targets for the monochromatized photons. All products of photon-ion interactions along the merge path of 0.3 to 1 m can be mass/charge separated with complete collection and almost 100 % detection efficieny. Accurate beam profile measurements allow for the determination of absolute cross sections. Scanning the photon energy in fine steps at resolving powers up to 40 000 delivers detailed spectroscopic information about excited states of the ions. Besides atomic ions also fullerene ions and endohedral fullerenes with encapsulated atomic ions have been studied. Time reversal symmetry relates photoionization to electron-ion recombination and provides new detailed insight into both processes. A particularly interesting subject of photon-ion studies is the response of endohedral fullerenes to photoabsorption by the atom encaged inside a carbon sphere. In comparison with a free ion, a significant redistribution of oscillator strengths is observed when the ion is encapsulated inside a fullerene cage. Also, evidence for containment resonances has been found. They arise from interference of photo-electron waves emitted by the central atom and then partially reflected back and forth by the fullerene sphere.

Invited Talk A 14.2 Fri 11:00 BAR 106

Doppler effect in fragment autoionization following core-to-

valence excitation in molecular oxygen. — •Marc Simon[1], Renaud Guillemin[1], and Eiji Shigemasa[2] — [1]Laboratoire de Chimie Physique-Matière et Rayonnement, 11 rue Pierre et Marie Curie, 75005 Paris, France — [2]Ultraviolet Synchrotron Orbital Radiation Facility, Institute for Molecular Science, Okazaki 444-8585, Japan

Nuclear motion in ultrafast dissociation of core excited molecules can be probed by the Doppler effect in emitted Auger electrons as experimentally first evidenced at the core-to-valence excitation in molecular oxygen by Björneholm et al. [1].

We address the question of multiple Auger decay. Although cascade Auger decay has been known and studied for a long time in atoms, a detailed study of cascade Auger decay following resonant core excitation in a molecule, namely CO, was reported only recently [2].

We report the observation of a Doppler effect in secondary Auger electron emission from excited atomic oxygen fragments created after core 1s excitation in molecular oxygen [3].

References

[1] O. Björneholm et al., Phys. Rev. Lett. 84, 2826 (2000). [2] L. Journel et al., Phys. Rev. A 77, 042710 (2008). [3] R. Guillemin et al., Phys. Rev. A 82, 051401 (2008).

A 14.3 Fri 11:30 BAR 106

Non Sequential Double Ionization of Lithium — •Michael Schuricke, Gopisankararao Veeravalli, Christian Dornes, Katharina Joachimsmeyer, Moritz Kurka, Alexander Dorn, and Joachim Ullrich — Max Planck Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The most simple and fundamental non-linear multi-electron reaction is double ionization by the absorption of two photons. In a series of benchmark experiments on helium indirect but nonetheless clean information about the distinct reaction channels, in sequential and non sequential double ionization (SDI, NSDI), has been gained by studying the recoil ion momentum. In a new experiment two-photon double ionization of magneto-optically trapped lithium was investigated in a Reaction Microscope (MOT-REMI), again recording the recoil ion momentum with utmost resolution. Due to the structure of lithium with the two tightly bound inner shell and the loosely bound valence electrons, strongly different contributions of the various double ionization mechanisms as compared to helium are expected. While, for example, the NSDI amplitude of helium is partly due to the simultaneous absorption of one photon by each of the electrons, the analogous process is strongly suppressed in the $Li(1s^2 2s) + 2\gamma \rightarrow Li^{2+}(1s)$ reaction. Here the small binding energy of the outer electron reduces the absorption of vuv-light. Hence, the NSDI amplitude is governed by two-photon absorption of a K-shell electron and electron correlation.

A 14.4 Fri 11:45 BAR 106

Interaction of atoms with strong fields: Time propagation of electron wave packets with the Solov'iev-Fatunla method — •Johannes Eiglsperger[1,2], Aliou Hamido[3], Javier Madroñero[1], and Bernard Piraux[3] — [1]Physik Department, Technische Universität München, Germany — [2]Institut für Theoretische Physik, Universität Regensburg, Germany — [3]Institute of Condensed Matter and Nanosciences, Université catholique de Louvain, Belgium

The study of the quantum dynamics of driven complex atomic systems is a fundamental problem in atomic physics and a challenge for both experiments and theory. The recent development of new XUV laser sources have opened the route to the study of multiphoton multiple ionization or excitation of atoms at high frequency and intensity. This poses new challenges for both theoreticians and experimentalists. From the theoretical point of view the validity of strong field approximations is questionable. More accurate techniques for the solution of the time-dependent Schrödinger equation (TDSE) are necessary. We present a promising alternative for the treatment of the TDSE which combines an explicit method adapted to solve systems of stiff equations [1,2] and a time-dependent scaling transformation of the coordinates [3]. With this approach we have investigated the influence of the atomic structure on the low energy part of the Above-Threshold-Ionization spectrum for a model potential and the hydrogen atom.

[1] O. Fatunla, Math. Comput. 34, 373 (1980).
[2] J. Madroñero and B. Piraux, Phys. Rev. A 80, 033409 (2009).
[3] E. A. Soloviev and S. I. Vinitsky, J. Phys. B 18, L557 (1985).

A 14.5 Fri 12:00 BAR 106

Excitons, polaritons and entanglement with x-ray light — •Adriana Pálffy, Christoph H. Keitel, and Jörg Evers — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Resonant scattering of monochromatized synchrotron radiation off nuclei can lead to an excitation in the nuclear ensemble that is of excitonic nature such that collective effects determine the coherent reemission. It has been shown experimentally [1] that switching abruptly the direction of the magnetic hyperfine fields can control and even completely suppress the coherent decay channel due to destructive interference.

Based on this switching technique, we investigate more advanced coherent control schemes and show that the accelerated nuclear forward scattering allows for the generation of two correlated coherent decay pulses out of one excitation, providing single-photon entanglement in the keV regime [2]. With a proper choice of switching parameters, specific transitions between hyperfine levels can be restored thus controlling the polarization of the emitted x-ray light [3]. Furthermore, suppression of the coherent decay in resonant x-ray scattering can be used to control the cooperative branching ratio in nuclear systems, and thus the population of nuclear states [4]. Prospects for the population of metastable nuclear states are discussed.

[1] Y. V. Shvyd'ko *et al.*, Phys. Rev. Lett. 77, 3232 (1995)
[2] A. Pálffy, C. H. Keitel and J. Evers, Phys. Rev. Lett. 103, 017401 (2009)
[3] A. Pálffy and J. Evers, J. Mod. Opt. 57, 1993 (2010)
[4] A. Pálffy, C. H. Keitel and J. Evers, arXiv:1010.5134

A 14.6 Fri 12:15 BAR 106

Photon-induced fluorescence spectroscopy (PIFS) — •Philipp Reiss, André Knie, and Arno Ehresmann — Universität Kassel, Institut für Physik und Center for Interdisciplinary Nanostructure Science and Technology, Heinrich Plett Str. 40, 34132 Kassel, Germany

Fluorescence spectroscopy and polarimetry of atoms and molecules is a versatile tool to investigate the final or intermediate decays of the ionic or neutral product. Over several years an apparatus has been built for this purpose.

This PIFS apparatus is designed to operate at synchrotron radiation beamlines, having synchrotron radiation as the excitation source of the atoms or molecules. The fluorescence light is dispersed by two 1m-normal-incidence monochromators and detected by position-sensitive single photon counting detectors. With interchangeable gratings and detectors, the observable range covers 45–800nm. It is possible to extract in a certain spectral range the linear and circular degree of polarization.

Some examples for application of this device is shown, demonstrating the different application fields.

A 14.7 Fri 12:30 BAR 106

Kohärente Anregung von Neon durch XUV-Kurzpulsstrahlung — •Jürgen Plenge, Andreas Wirsing, Christopher Raschpichler und Eckart Rühl — Institut für Chemie und Biochemie, Freie Universität Berlin, Takustr. 3, 14195 Berlin

Die kohärente Anregung von Atomen durch geformte Femtosekunden-Laserpulse kann aufgrund der Interferenz zwischen resonanten und nicht-resonanten Anregungspfaden zur Bildung von kohärenten Transienten führen. Es werden Experimente vorgestellt, in denen die kohärente Anregung von 3d-Rydbergzustände in Neon und die Bildung eines Wellenpakets durch phasenmodulierte XUV-Kurzpulstrahlung untersucht wurde. Die Zustände $2p^5(^2P_{3/2})3d[1/2]$ und $2p^5(^2P_{3/2})3d[3/2]$ wurden durch die 13. Harmonische ($h\nu = 20,04$ eV) eines Titan-Saphir Femtosekunden-Lasersystems angeregt und die Population der angeregten Zustände durch Ionisation mit einen zeitverzögerten 804-nm-Laserpuls nachgewiesen. Die zeitabhängige Photoelektronenausbeuten zeigen charakterische Oszillationen, die auf die Anregung von kohärenten Transienten und die Dynamik eines Wellenpakets zurückgeführt werden. Die Experimente zeigen, dass sich die kohärente transiente Anregung von Neon und die Dynamik des Wellenpakets durch die spektrale Phase der 13. Harmonischen kontrollieren lassen, wobei die Stärke der Modulation der spektralen Phase des XUV-Pulses durch die Wechselwirkung mit einem resonanten Gasfilter variabler Dichte erreicht wird. Damit ist die Möglichkeit der Kontrolle von Anregungsprozessen im XUV-Bereich durch phasenmodulierte höhere Harmonische gegeben.

A 15: Ultra-cold atoms, ions and BEC III (with Q)

Time: Wednesday 10:30–12:45 Location: BAR 106

Invited Talk A 15.1 Wed 10:30 BAR 106
Ultracold chemistry and dipolar collisions in a quantum gas of polar molecules — •Silke Ospelkaus[1,2], Amodsen Chotia[2], Marcio de Miranda[2], Brian Neyenhuis[2], Kang-Kuen Ni[2], Dajun Wang[2], Jun Ye[2], and Deborah Jin[2] — [1]Institut fuer Quantenoptik und QUEST, Universitaet Hannover — [2]JILA, NIST and University of Colorado, Boulder, CO, USA

Ultracold polar molecular quantum gases promise to open new research directions ranging from the study of ultra-cold chemistry, precision measurements to novel quantum phase transitions. Based on the preparation of high-phase space density gases of polar KRb molecules [1,2,3], I will discuss the control of dipolar collisions and chemical reactions of polar molecules in a regime where quantum statistics, single scattering partial waves, and quantum threshold laws play a dominant role [4]. In particular, I will point out the crucial role of electric dipole-dipole interactions [5] and external confinement [6] in determining the chemical reaction rate. Finally, I will discuss prospects of reaching quantum degeneracy in bi-alkali samples of polar molecules and prospects for these systems as novel dipolar quantum many-body systems. [1] K. K. Ni, S. Ospelkaus, M. H. G. de Miranda, et al., Science 322, 231 (2008). [2] S. Ospelkaus, K. K. Ni, M. H. G. de Miranda, et al., Faraday Discussions 142, 351 (2009). [3] S. Ospelkaus, K. K. Ni, G. Quemener, et al., Phys. Rev. Lett. 104, 030402 (2010). [4] S. Ospelkaus, K. K. Ni, D. Wang, et al., Science 327, 853 (2010). [5] K. K. Ni, S. Ospelkaus, D. Wang, et al., Nature 464, 1324 (2010). [6] M. H. G. de Miranda, A. Chotia, B. Neyenhuis et al, arXiv: 1010.3731 (2010).

A 15.2 Wed 11:00 BAR 106
Finite temperature interactions between cold atoms and nanostructures — Johannes Märkle, Benjamin Jetter, Philipp Schneeweiss, Michael Gierling, Gabriela Visanescu, Peter Federsel, Dieter Kern, Andreas Günther, József Fortagh, and •Thomas Judd — CQ Center for Collective Quantum Phenomena and their Applications, Eberhard-Karls-Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

There is currently much interest in combining cold atoms with nanofabricated devices such as carbon nanotubes. Such research studies the interface between quantum gases and solid devices, and the interface between quantum and classical physics. It also provides insight into nanomachines, nanoelectronics, and macromolecular control. In such systems the role of temperature is important and related to quantum coherence properties.

Here we study quantum reflection and inelastic scattering of atoms from carbon nanotubes and show how cold atom experiments can extract information about nanostructures' van der Waals potentials. We also develop a novel finite temperature theory for cold atoms and study how solid structures may be used to cool and create coherence in quantum gases. We also explore the reverse case in which a cold atom cloud is used to cool solid objects.

A 15.3 Wed 11:15 BAR 106
Dark solitons near the Mott-insulator–superfluid phase transition — •Konstantin Krutitsky[1], Jonas Larson[2,3], and Maciej Lewenstein[4,5] — [1]Fakultät für Physik der Universität Duisburg-Essen, Campus Duisburg, Lotharstraße 1, 47048 Duisburg, Germany — [2]NORDITA, 106 91 Stockholm, Sweden — [3]Department of Physics, Stockholm University, AlbaNova University Center, 106 91 Stockholm, Sweden — [4]ICFO-Institut de Ciències de Fotòniques, 008860 Castelldefels (Barcelona), Spain — [5]ICREA-Institució Catalana de Recerca i Estudis Avançats, Lluís Companys 23, 08010 Barcelona, Spain

Dark solitons of ultracold bosons in the vicinity of the Mott-insulator–superfluid phase transition are studied. Making use of the Gutzwiller ansatz we have found antisymmetric eigenstates corresponding to standing solitons, as well as propagating solitons created by phase imprinting. Near the phase boundary, superfluidity has either a particle or a hole character depending on the system parameters, which greatly affects the characteristics of both types of solitons. Within the insulating Mott regions, soliton solutions are prohibited by lack of phase coherence between the lattice sites. Linear and modulational stability show that the soliton solutions are sensitive to small perturbations and, therefore, unstable. In general, their lifetimes differ for on-site and off-site modes. For the on-site modes, there are small areas between the Mott-insulator regions where the lifetime is very large, and in particular much larger than that for the off-site modes.

A 15.4 Wed 11:30 BAR 106
Overview of laser cooling of relativistic C3+ ion beams at ESR — •Michael Bussmann[1], Franziska Kroll[1], Markus Löser[1], Matthias Siebold[1], Ulrich Schramm[1], Weiqiang Wen[1,2,6], Daniel F.A. Winters[2,3], Tobias Beck[4], Benjamin Rein[4], Thomas Walther[4], Gerhard Birkl[4], Wilfried Nörtershäuser[2,5], Thomas Kühl[2], Christian Novotny[2,5], Christophor Kozhuharov[2], Christopher Geppert[2,5], Markus Steck[2], Christina Dimopoulou[2], Fritz Nolden[2], Xinwen Ma[6], and Thomas Stöhlker[2,3] — [1]Forschungszentrum Dresden-Rossendorf — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH — [3]Universität Heidelberg — [4]Technische Universität Darmstadt — [5]Universität Mainz — [6]Institute for Modern Physics, Chinese Academy of Science

We present an overview of the setup for all-optical cooling and beam diagnostics for relativistic C3+ ion beams at the Experimental Storage Ring (ESR) at GSI. With new optical diagnostics it is foreseen to improve the measurement of the longitudinal momentum spread of the beam by at least an order of magnitude. The new optical diagnostics together with the new Schottky diagnosis and beam profile monitor available at ESR will allow to access the complete phase space evolution of the beam inside the storage ring. With new laser systems developed for cooling beams with an initially large energy spread it will be possible to replace the electron cooler that was used to reduce the initial momentum spread of the ion beam.

A 15.5 Wed 11:45 BAR 106
Stability and elementary excitations of a dipolar Bose gas in a 1D optical lattice — •Mattia Jona - Lasinio[1], Luis Santos[1], Stefan Mueller[1,2], Juliette Billy[2], Emanuel Henn[2], Holger Kadau[2], Philipp Weinmann[2], David Peter[2], and Tilman Pfau[2] — [1]ITP, Institut für Theoretische Physik, Leibniz Universität Hannover — [2]5. Physikalisches Institut, Universität Stuttgart

We consider a system of ultracold dipolar bosons in a 3D harmonic potential plus a 1D optical lattice along the weakest trapping direction. We assume all dipoles to be aligned along the lattice direction. We investigate the stability of the system as a function of the lattice strength and we highlight the role played by the long range dipole-dipole interaction. By solving the Bogoliubov equations we also characterize the different types of instability emerging in the system. We compare our theoretical predictions with the stability of a Chromium (^{52}Cr) condensate, finding the experimental evidence of the dipole-dipole long range character.

A 15.6 Wed 12:00 BAR 106
Stability of a Dipolar Quantum Gas in a 1D Optical Lattice — •Stefan Mueller[1,2], Juliette Billy[1], Emanuel Henn[1], Holger Kadau[1], Philipp Weinmann[1], David Peter[1], Mattia Jona Lasinio[2], Luis Santos[2], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart — [2]Cluster of Excellence QUEST, Institut für Theoretische Physik, Leibniz Universität Hannover

We present first measurements on the stability of a BEC of chromium atoms in a 1D optical lattice. In a shallow lattice the trap aspect ratio of the underlying optical dipole trap (ODT) potential determines the critical scattering length [1]. However, in a deep lattice the system can be considered as a stack of pancake shape BECs, which individually are expected to be much more stable. We investigate the range from 0 to approx. 100 recoil energies lattice depth, observing a continuous decrease in the critical scattering length from +13 to -20 Bohr radii. Theoretical studies support significant intersite coupling via the long range dipole-dipole interactions.

[1] T.Koch *et al.*: Nature Physics **4**, 218 (2008)

A 15.7 Wed 12:15 BAR 106
Controlled Charge Transport in lattice confined Alkaline-Earth Gases — •Rick Mukherjee[1], Alexander Eisfeld[1], Igor Lesanovsky[2], and Thomas Pohl[1] — [1]Max Planck Institute for the

Physics of Complex Systems, Dresden, Germany — [2]School of Physics and Astronomy, The University of Nottingham, United Kingdom

We study the dynamics of an ion immersed in an optical lattice of ultracold atoms. Here, simultaneous trapping of atoms and ions is made possible though the use of alkaline-earth atoms. Focussing on Strontium, we present extensive calculations of the atomic structure of highly excited states, as well as of the properties of molecular ions composed of such two-electron atoms. Optical dressing to Rydberg states is shown to permit precise and detailed control of charge exchange between neighbouring lattice sites, thereby offering unique opportunities to steer coherent charge transport and implement, e.g. a range Holstein-Hubbard type Hamiltonians in optical lattices.

A 15.8 Wed 12:30 BAR 106

Mixing and de-mixing of dressed condensates — •Eike Nicklas, Helmut Strobel, Christian Gross, Tilman Zibold, Jiri Tomkovic, and Markus K Oberthaler — Kirchhoff Institute for Physics, University of Heidelberg, Germany

Two component interacting Bose-Einstein condensates provide a versatile system for studying the dynamics of multicomponent quantum fluids. Here we report on a method for controlling the effective interactions that govern the miscibility of the system by dressing the two components with a linear coupling field. We experimentally investigate the demixing dynamics of a binary condensate consisting of two hyperfine states of Rubidium and compare the results with numerical simulations. A Feshbach resonance allows changing the miscibility parameter of the system. We observe suppression of demixing when the two components are dressed with a linear coupling and the effective miscibility can be controlled via the coupling strength. Furthermore, we find that a miscible system is destabilized when applying a driving field.

A 16: Atomic systems in external fields I

Time: Wednesday 14:00–16:00 Location: BAR 106

A 16.1 Wed 14:00 BAR 106

Parity-Violation in Hydrogen: Precision Enhancement through Many-Particle Squeezing — •Martin-Isbjörn Trappe, Thomas Gasenzer, and Otto Nachtmann — Institut für Theoretische Physik, Philosophenweg 16, 69120 Heidelberg

We discuss the propagation of hydrogen atoms in static electric and magnetic fields in a longitudinal atomic beam spin echo (lABSE) Interferometer. The atoms acquire geometric (Berry) phases that exhibit a manifestation of parity-(P-)violation effects arising from electroweak Z-boson exchange between electron and nucleus. We provide analytical as well as numerical calculations of the behaviour of the metastable n=2 states of hydrogen. Possible measurements of P-violating geometric phases in lABSE experiments require a high precision for detecting atoms in specific states. We investigate possibilities to enhance the precision of lABSE experiments beyond the standard quantum limit using squeezed many-particle hydrogen states.

A 16.2 Wed 14:15 BAR 106

On the applicability of the Floquet theorem to TDDFT — •Varun Kapoor and Dieter Bauer — Institut für Physik, Universität Rostock, 18051 Rostock, Germany

We investigate the applicability of the Floquet ansatz to time-dependent density functional theory (TDDFT). We find that the periodicity of the TDDFT-Hamiltonian with just the laser period, as required by the Floquet ansatz, is conditional. We obtain the exact Hartree-exchange-correlation potential for exactly solvable model systems and Fourier transform it to check for periodicity of the TDDFT-Hamiltonian. We find that only if the ground state evolves adiabatically in the laser field and the laser frequency is non-resonant, Floquet-TDDFT states exist and the Floquet ansatz is applicable. We use the novel Floquet analysis we developed to obtain the populated Floquet states which qualitatively agree with the populated Floquet states obtained by solving the Schrödinger equation. A comparison is also made between Floquet-TDDFT states obtained by exact and Hartree-exchange-only TDDFT.

A 16.3 Wed 14:30 BAR 106

Resonance wave functions located at the Stark saddle point — •Holger Cartarius[1], Jörg Main[2], Thorsten Losch[2], and Günther Wunner[2] — [1]Chemical Physics Department, Weizmann Institute of Science, 76100 Rehovot, Israel — [2]1. Institut für Theoretische Physik, Universität Stuttgart , 70550 Stuttgart, Germany

The hydrogen atom in crossed static electric and magnetic fields is an important example for a quantum system accessible both in experiments and numerical calculations. Adding external fields to the Coulomb potential of the hydrogen atom opens the possibility for wave functions to be localized far away from the nucleus. In particular, the existence of resonances localized in the vicinity of the Stark saddle point predicted by simple expansions of the potential around the saddle [1] has been unclear for a long time.

We calculate quantum mechanically exact wave functions of resonances in spectra of the hydrogen atom in crossed external fields and prove the existence of the long-lived decaying quantum states localized at the Stark saddle point [2]. A spectrum of ground and excited states reproducing the nodal patterns expected from simple quadratic and cubic expansions of the potential in the vicinity of the saddle can be identified.

[1] C. W. Clark, E. Korevaar, and M. G. Littman, Phys. Rev. Lett. **54**, 320 (1985)
[2] H. Cartarius, J. Main, T. Losch, and G. Wunner, Phys. Rev. A **81**, 063414 (2010)

A 16.4 Wed 14:45 BAR 106

Classical approaches to quantum dynamical systems — •Heiko Bauke and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Quantum dynamical systems are often investigated by classical or semi-classical approaches. Classical methods are applied when a full quantum mechanical treatment is not feasible. They allow to work in the framework of familiar classical concepts and to investigate the quantum-to-classical transition [1]. However, the limits of classical approaches to quantum dynamical systems are often not very well understood.

In our contribution, we investigate the validity and the limits of the classical trajectory Monte Carlo method [2] by comparing the dynamics of non-interacting classical particles under the evolution of the Liouville equation with the quantum dynamics in phase space under the quantum Liouville equation. Our results allow us to estimate in which setups quantum effects become non-negligible. We show that a modified classical trajectory Monte Carlo method becomes equivalent to the actual quantum dynamics in the limit that all forces are harmonic. This method allows us to study timde-dependent processes in driven many particle quantum systems with harmonic interactions.

[1] *Quantum-Classical Correspondence*, Josef Bolitschek, Springer, 2004
[2] Proceedings of the Physical Society, **88**:861, 1966; Proceedings of the Physical Society, **88**:873, 1966

A 16.5 Wed 15:00 BAR 106

Alignment of atomic inner-shell vacancies following nuclear α decay — •Sean McConnell[1,2] and Andrey Surzhykov[1,2] — [1]Physikalisches Institut der Universität Heidelberg — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt

The alpha decay of Polonium has the potential to induce the ionisation of any of the electrons initially bound to the nucleus. Should this process involve the ionisation of an electron from the L_3 sub-shell, the remaining hole may appear to be aligned. In order to estimate such an alignment, theoretical calculations were performed in Ref. [1] based, however, on solutions of the non-relativistic Schrödinger equation. Moreover, that work did not account for shake–off or recoil effects that may significantly influence the inner-shell ionisation process. In this contribution, we present a fully-relativistic description of the inner-shell ionisation with a special emphasis on the alignment of the residual atom. Our theoretical treatment includes not only nuclear shake-off effects and compensation for the realistic motion of the α particle as it escapes from the daughter Lead nucleus, but also accounts for electron screening effects. To understand better the role of these effects on the alignment of the $2p_{3/2}$ vacancy, detailed calculations are performed for a wide range of common α particle energies and have been compared with previous data. We can demonstrate through our calculations, that as well as the aforementioned disregard of shake-off and recoil corrections among other important factors, non-negligible inaccuracies have surfaced in previous estimations of alignment.

[1] N M Kabachnik, J. Phys. B: At., Mol., Phys. **18(13)** (1985) L423

A 16.6 Wed 15:15 BAR 106

Global fixed point proof for time-dependent density functional theory — •Michael Ruggenthaler and Robert van Leeuwen — Department of Physics, Nanoscience Center, University of Jyväskylä, 40014 Jyväskylä, Finland

Time-dependent density-functional theory is the extension of the highly successful ground-state density-functional theory to time-dependent phenomena. The basic theorem by Runge and Gross [1] shows under the assumption of Taylor-expandable external potentials that every observable is in principle uniquely defined by the one-particle density of the quantum system. The van Leeuwen theorem [2] provides under similar restrictions, that there is an auxiliary system of noninteracting particles generating the exact density of the interacting system. This so-called Kohn-Sham construction makes an ab initio solution for big quantum systems feasible. By rewriting the question whether a system is uniquely defined by its density as a fixed point question, we can proof both theorems without assumptions on the time-dependence of the potentials. We discuss implications and applications of this novel approach to fundamental questions of many-body physics.

[1] E. Runge and E.K.U. Gross, Phys. Rev. Lett. **52**, 997 (1984).
[2] R. van Leeuwen, Phys. Rev. Lett. **82**, 3863 (1999).

A 16.7 Wed 15:30 BAR 106

Ultra-fast calculation of bound atomic states and transitions in neutron star atmospheres with very strong magnetic fields — •Christoph Schimeczek and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart

X-ray absorption spectra of neutron stars contain broad line features which still defy interpretation but are most likely due to electromagnetic transitions of atoms and ions contained in the hot thin atmosphere covering the neutron stars. The presence of a very strong magnetic field with about 10^8T distorts all atomic structures and creates totally new spectral behaviour. We developed an ultra-fast Hartree-Fock-Roothaan code to calculate atomic states and transition rates under such abnormal conditions with high precision and set up a database of up to now a hundred thousand unique atomic states. This data can serve as input for quantitative model atmosphere calculations, which will ultimately clarify the physical properties of the atmosphere.

A 16.8 Wed 15:45 BAR 106

Hartree-Fock calculations for the photoionization of atoms and ions from hydrogen to iron in neutron star magnetic fields — •Peter Diemand, Thorsten Kersting, Damir Zajec, and Günter Wunner — 1. Institut für theoretische Physik, Universität Stuttgart

We derive the photoionization cross section in dipole approximation for many-electron atoms and ions in neutron star magnetic field strengths. Continuum states are treated in adiabatic approximation in a self-consistent way. Bound states are calculated by solving the Hartree-Fock-Roothaan equations using finite-element and B-spline techniques. The data are of importance for the quantitative interpretation of observed X-ray spectra that originate from the thermal emission of isolated neutron stars. They can serve as input for modelling neutron star atmospheres as regards chemical composition, magnetic field strength, temperature, and redshift. We demonstrate example results for astrophysically relevant atoms and ions in the range Z=1,...26.

A 17: Ultra-cold atoms, ions and BEC IV (with Q)

Time: Wednesday 16:30–18:00 Location: BAR 205

A 17.1 Wed 16:30 BAR 205

Quantum dynamics of strongly interacting bosonic mixture. — •Budhaditya Chatterjee[1], Ioannis Brouzos[2], and Peter Schmelcher[2] — [1]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg, Germany — [2]Zentrum für Optische Quantentechnologien, Luruper Chaussee 149, 22761 Hamburg, Germany

We look at tunneling dynamics of strongly correlated bosonic mixture. The effect of the inter- and the intra-species interaction and their interplay is investigated using the numerically exact Multi-Configuration Time dependent Hartree (MCTDH) method. Dynamics is calculated for two initial configurations- complete population imbalanced state and phase separated state. Increasing the inter-species interaction leads to an exponential increase in the tunneling time period analogous to the quantum self-trapping for condensates. The increase of the intra-species repulsion elongates the tunneling period for small inter-species correlations while in the opposite case of stronger interaction it enhances the tunneling. These effects are explained by studying the spectra and the stationary states. The effect of higher particle number as well as number symmetry is discussed.

A 17.2 Wed 16:45 BAR 205

Atomic homodyne detection of two mode squeezed states — •Helmut Strobel, Christian Gross, Eike Nicklas, Tilman Zibold, Jiri Tomkovic, and Markus K Oberthaler — Kirchhoff Institute for Physics, University of Heidelberg, Germany

In quantum optics homodyning is a very successful and widely used measurement technique that reveals the quadratures of the electric field. Its counterpart for Quantum Atom Optics, the measurement of the quadratures of a matter wave field, has not been realized so far. Here we present a homodyne measurement of the matter wave quadratures of two mode squeezed atomic quantum states produced by spin changing collisions in a Bose-Einstein condensate. Our measurements reveal strong correlation between the two largely occupied modes and show the existence of a non-vanishing pair phase, i.e. pair coherence. The observed noise level in the two mode quadratures is below the threshold expected for classical states and hence flags entanglement in the system.

A 17.3 Wed 17:00 BAR 205

Observation of new Feshbach Resonances in Sodium-Lithium Mixtures — •Tobias Schuster, Raphael Scelle, Arno Trautmann, Steven Knoop, and Markus K. Oberthaler — Kirchhoff Institut für Physik, Universität Heidelberg, Im Neuenheimer Feld 227, 69120 Heidelberg

We report on studies of Feshbach resonances in an ultracold Bose-Fermi mixture of ^{23}Na and ^{6}Li. The experimentally observed spectra of resonances cover magnetic fields of more than 2kG and different spin channels. Our findings are explained in terms of the Asymptotic Bound-state Model, which gives a comprehensive explanation of our experimental results, differing substantially from previous theoretical predictions [1]. Possible applications of this ultracold Bose-Fermi mixture are discussed.

[1] M. Gacesa, P. Pellegrini, and R. Cote, Phys. Rev. A **78**, 010701(R) (2008)

A 17.4 Wed 17:15 BAR 205

Spinor Bose-Einstein condensates in optical superlattices — •Andreas Wagner and Christoph Bruder — University of Basel

We examine spinor Bose-Einstein condensates in optical superlattices theoretically using a Bose-Hubbard hamiltonian which takes spin effects into account. Assuming that a small number of spin-one bosons is loaded in an optical potential, we study single-particle tunneling which occurs when one lattice site is ramped up relative to a neighbouring site. Spin-dependent effects modify the tunneling events in a qualitative and a quantitative way. We use a double-well potential as a unit cell of a one-dimensional superlattice and a four-well square-shaped potential as a unit cell of a two-dimensional superlattice. Homogeneous and inhomogeneous magnetic fields lead to spin-flip transitions and various other effects. E.g. it is possible for the four-well potential to observe spin-ordered states and non-trivial tunneling events, i.e.

events at which at one site the particle number increases although the potential energy increases simultaneously. Finally, we investigate the bipartite entanglement between single sites and the remainder of the system and construct states of maximal entanglement.

A 17.5 Wed 17:30 BAR 205

New Efimov resonances in an ultracold cesium gas — •Alessandro Zenesini[1], Martin Berninger[1], Bo Huang[1,2], Stefan Besler[1], Hanns-Christoph Nägerl[1], Francesca Ferlaino[1], and Rudolf Grimm[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, 6020 Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, 6020 Innsbruck, Austria

Efimov trimer states represent the paradigm of universality in few-body physics. Although these exotic three-body weakly-bound states have been experimentally investigated in an increasing number of ultracold atomic systems, many fundamental aspects remain unclear [1]. An intriguing open question is related to how short-range physics influences the Efimov effect in real systems. Short range contributions are commonly included in universal theory via a single parameter, known as "three-body parameter". An open question is whether this parameter is constant or whether it can vary significantly when Feshbach resonances are employed for interaction tuning. Cesium is a very promising candidate to address this issue because of the many broad and narrow Feshbach resonances with different partial-wave character. Our experimental results reveal new Efimov features close to different Feshbach resonances and shed new light on the three-body parameter.

[1] "Forty years of Efimov physics: How a bizarre prediction turned into a hot topic" F. Ferlaino and R. Grimm, Physics 3, 9 (2010)

A 17.6 Wed 17:45 BAR 205

Structural Defects in Ion Chains by Quenching the External Potential: The Inhomogeneous Kibble-Zurek Mechanism — Giovanna Morigi[2], Adolfo Del Campo[1], Gabriele De Chiara[3], Martin Plenio[1], and •Alex Retzker[1] — [1]Universitaet Ulm, Ulm, Germany — [2]Universität des Saarlandes, Saarbrücken, Germany — [3]Universitat Autonoma de Barcelona, Barcelona, Spain

The nonequilibrium dynamics of an ion chain in a highly anisotropic trap is studied when the transverse trap frequency is quenched across the value at which the chain undergoes a continuous phase transition from a linear to a zigzag structure. Within Landau theory, an equation for the order parameter, corresponding to the transverse size of the zigzag structure, is determined when the vibrational motion is damped via laser cooling. The number of structural defects produced during a linear quench of the transverse trapping frequency is predicted and verified numerically. It is shown to obey the scaling predicted by the Kibble-Zurek mechanism, when extended to take into account the spatial inhomogeneities of the ion chain in a linear Paul trap.

A 18: Interaction with strong or short laser pulses I

Time: Wednesday 16:30–18:30 Location: BAR 106

A 18.1 Wed 16:30 BAR 106

Controlling quantum beat structures in the photoionization continuum of neon — •Henning Geiseler, Horst Rottke, Günter Steinmeyer, and Wolfgang Sandner — Max-Born-Institut, Max-Born-Str. 2a, 12489 Berlin

The coherent excitation of an ensemble of high lying bound states in an atomic system by an ultrashort XUV pulse, followed by ionization of these states with a delayed IR probe pulse leads to quantum beats in the delay dependent photoelectron spectrum. We performed measurements of these quantum beats in neon, observing a dependence on the ionization pulse intensity. To account for this dependence, we developed a model that involves an IR laser pulse induced coupling of the bound states, which are excited by the XUV pulse, to a lower lying state in the neon atom.

A 18.2 Wed 16:45 BAR 106

High-Harmonic Generation via Continuum-Wave Packet Interference — •Markus C. Kohler, Christian Ott, Philipp Raith, Robert Heck, Ines Schlegel, Christoph H. Keitel, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

High-Harmonic Generation is investigated theoretically in the over-the-barrier ionization regime revealing a significant coherent radiation response of continuum-continuum (CC) harmonics. Their emission happens when two parts of the electronic wave function being ionized in different half cycles of the laser recollide at the same time. The emission energy of these CC harmonics is exactly the kinetic-energy difference of the two wave packets.

A time-frequency analysis shows that the process entirely dominates coherent HHG emission after the ground state has been depleted. Moreover, we show that CC harmonics exhibit a different phase-matching behavior compared to the traditional continuum-bound harmonics and can therefore be isolated. Our analytic results suggest that CC harmonics might be employed for a new type of molecular tomography where the potential-energy landscape of a molecule could be imaged. Additionally, we advance the interference model of HHG.

[1] Markus C. Kohler, Christian Ott, Philipp Raith, Robert Heck, Iris Schlegel, Christoph H. Keitel, and Thomas Pfeifer, Phys. Rev. Lett 105, 203902 (2010)

A 18.3 Wed 17:00 BAR 106

Low-Energy Structures in Strong Field Ionization Revealed by Quantum Orbits — •Tian-Min Yan[1,2], Sergey Popruzhenko[3], Marc Vrakking[4,5], and Dieter Bauer[1] — [1]Institut für Physik, Universität Rostock, 18051 Rostock, Germany — [2]Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg, Germany — [3]National Research Nuclear University "Moscow Engineering Physics Institute", Kashirskoe Shosse 31, 115409, Moscow, Russia — [4]FOM-Institute AMOLF, Science Park 113, 1098 XG Amsterdam, The Netherlands — [5]Max-Born-Institut, Max-Born-Straße 2A, 12489 Berlin, Germany

Experiments on atoms in intense laser pulses and the corresponding exact ab initio solutions of the time-dependent Schrödinger equation (TDSE) yield photoelectronic spectra with low-energy features that are not reproduced by the otherwise successful work horse of strong field laser physics: the "strong field approximation" (SFA). In the semi-classical limit, the SFA possesses an appealing interpretation in terms of interfering quantum trajectories. It is shown [1] that a conceptually simple extension towards the inclusion of Coulomb effects yields very good agreement with exact TDSE results. Moreover, the Coulomb quantum orbits allow for a physically intuitive interpretation and detailed analysis of all low-energy features in the semi-classical regime, in particular the recently discovered "low-energy structure" [2,3].

[1] Tian-Min Yan, S.V. Popruzhenko, M.J.J. Vrakking, D.Bauer, Phys. Rev. Lett. (in press). [2] C.I. Blaga et al., Nature Physics 5, 335 (2009). [3] W. Quan et al., Phys. Rev. Lett. 103, 093001 (2009).

A 18.4 Wed 17:15 BAR 106

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

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

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

A 18.5 Wed 17:30 BAR 106

Pump-probe scattering experiments on exploding rare gas clusters at LCLS X-FEL — •Tais Gorkhover[1], Marcus Adolph[1], Daniela Rupp[1], Sebastian Schorb[1], Thomas Möller[2], Robert Hartmann[4], Daniel Rolles[3], Artem Rudenko[3], Ilme Schlichting[3,5], Lothar Strüder[4], Bill White[2], Joachim Ullrich[6], Ryan Coffee[2], and Christoph Bostedt[2] — [1]TU Berlin — [2]LCLS, Stanford — [3]ASG — [4]MPI HLL — [5]MPI MF — [6]MPI K

The interaction of strong, short laser pulses with large atomic clusters has become a vivid research field. The key point is the strongly increased energy absorption compared to single atoms, which has been shown for intense IR and up to VUV laser radiation. These results trigger an ongoing debate about the fs-fast absorption and recombination mechanisms, which happen during the cluster burst.

Our experiment gives a new insight by imaging the explosion dynamics at ~100 fs to 3 ps after the laser pulse in single shot modus. It was performed at the Linac Coherent Light Source (LCLS), which is recently the brightest available X-ray source with fs-pulse durations. Nm sized clusters were probed by the intense focused FEL beam after being irradiated with a strong, fs Ti:Sa pulse (800 nm). The cluster-pulse interaction was observed using simultaneously pnCCD detectors (scattering and fluorescence analysis) and ion /electron spectrometers (ionization processes insight). First results will be presented from both observation methods. This experiment was realized in the CFEL-ASG Multi-Purpose (CAMP) End Station.

A 18.6 Wed 17:45 BAR 106

Carrier-Envelope-Phase Effects in Non Sequential Double Ionization of Rare Gases — •Boris Bergues[1], Matthias Kübel[1], Nora G. Johnson[1,5], Kelsie J. Betsch[2], Robert R. Jones[2], Gerhard G. Paulus[3], Robert Moshammer[4], Joachim Ullrich[4], Ferenc Krausz[1], and Matthias F. Kling[1,5] — [1]Max-Planck-Institut für Quantenoptik, Garching, Germany. — [2]University of Virginia, Charlottesville, VA, USA — [3]Friedrich-Schiller-Universität, Jena, Germany — [4]Max-Planck-Institut für Kernphysik, Heidelberg, Germany. — [5]Kansas State University, Manhattan, KS, USA

Non-sequential Double Ionization (NSDI) of atoms in strong laser fields has been the subject of numerous experimental and theoretical studies. Yet, the mechanisms that govern this process are not fully understood. Advances in ultra-fast lasers technology have permitted the generation of light pulses with a duration close to a single optical cycle, which can be used to study quantum dynamics with attosecond time resolution. Using a reaction microscope in combination with the recently developed single-shot Carrier-Envelope-Phase (CEP) measurement technique, we investigate the sub-cycle dynamics of the NSDI process in Argon atoms exposed to near single-cycle laser pulses. Measurements of CEP-resolved two-electron coincidence spectra of NSDI are presented and discussed.

A 18.7 Wed 18:00 BAR 106

Correlated electron dynamics in high-order harmonic generation from H_2 — •Jing Zhao and Manfred Lein — Institut für Theoretische Physik and Centre for Quantum Engineering and Space-Time Research (QUEST), Leibniz Universität Hannover, Appelstraße 2, D-30167 Hannover, Germany

High-order harmonic generation from an H_2 model molecule is investigated by numerical solution of the two-electron Schrödinger equation. The harmonic spectrum is modulated by both structural and multi-electron dynamical interference effects. We reproduce the extrema by a simple model, based on the location of the hole left in the parent ion after ionization, the electronic wave-packet motion between ionization and recombination, and the recombination phase. Thus, the spectrum provides information about the location of the hole. It is found that the minimum at intermediate harmonic orders is mainly due to structural interference, while the minimum near the cutoff region is predominantly due to dynamical interference.

A 18.8 Wed 18:15 BAR 106

Ionization of atoms by strong infrared fields: Solution of the time-dependent Schrödinger equation in momentum space for a model based on separable potentials — Hugues Tetchou Nganso[1,2], Yuri Popov[3], Bernard Piraux[1], •Javier Madroñero[4], and Moïse Godfroy Kwato Njock[2] — [1]Université Catholique de Louvain, Belgium — [2]University of Douala, Cameroon — [3]Moscow State University, Russia — [4]Technische Universität München, Germany

We consider the ionization of atomic hydrogen by a strong infrared field. By starting from the corresponding time-dependent Schrödinger equation in momentum space, we develop a model in which the kernel of the non-local Coulomb potential is replaced by a finite sum of separable potentials. Each separable potential supports one bound state of atomic hydrogen. Here, we consider only the 1s, 2s and 2p states. In this way, the full 3-dimensional Schrödinger equation reduces to a system of a few coupled 1-dimensional linear Volterra integral equations. This model is a theoretical tool to understand the actual role of the atomic potential in the intensity regime where tunnel ionization is supposed to take place and where the experimental data for the first ATI peaks are in contradiction with the theoretical predictions based on the strong field approximation model.

A 19: Atomic clusters I

Time: Thursday 10:30–13:00 Location: BAR 205

Invited Talk A 19.1 Thu 10:30 BAR 205

Cluster ionization in strong laser fields - NIR vs. XUV — •Thomas Fennel, Jörg Köhn, Christian Peltz, and Mathias Arbeiter — Universität Rostock, 18051 Rostock, Germany

Clusters in intense laser pulses are valuable model systems for exploring new frontiers of ultrafast strong-field many-particle physics [1]. The understanding of key processes like collective excitations, ultrafast plasma creation, field amplification, and electron rescattering in clusters may open up new routes for the analysis and control of nanosystems with light. The talk will focus on two aspects: (i) waveform control of resonance enhanced electron emission in near-infrared pulses (NIR); (ii) ionization and heating behavior at short wavelength (XUV).

The first part discusses a scheme for efficient electron acceleration via resonant plasmonic effects [2], i.e. due to high transient polarization fields from resonant interaction of the laser with free cluster electrons. Numerical results for the directional control of the electron emission from metal clusters by the carrier-envelope phase of few-cycle laser fields will be presented [3]. The second part focusses on the ionization and heating of rare-gas clusters at high photon energy [4], where plasma heating disappears and photoionization dominates the laser-matter coupling. A two-color pump-probe scheme for the time-resolved analysis of the cluster dynamics is proposed.

[1] Th. Fennel et al., Rev. Mod. Phys. 82:1793 (2010)
[2] Th. Fennel et al., Phys. Rev. Lett. 98:143401 (2007)
[3] J. Köhn et al., in preparation
[4] M. Arbeiter and Th. Fennel, Phys. Rev. A, 82:013201 (2010)

A 19.2 Thu 11:00 BAR 205

Imaginary time Gaussian dynamics of rare gas clusters — •Holger Cartarius and Eli Pollak — Chemical Physics Department, Weizmann Institute of Science, 76100 Rehovot, Israel

Semiclassical Gaussian approximations to the Boltzmann operator have become an important tool for the investigation of thermodynamic properties of clusters of atoms at low temperatures. Usually, numerically expensive thawed Gaussian variants are applied. We introduce a numerically much cheaper frozen Gaussian approximation to the imaginary time propagator with a width matrix especially suited for the dynamics of clusters. The quality of the results is comparable to that of thawed Gaussian methods based on the single-particle ansatz. We apply the method to small rare gas clusters and investigate their dissociation processes. We also discuss the influence of an artificial confinement of the atoms usually introduced to converge numerical computations. The results show that restrictive confinements often implemented in studies of clusters can influence the thermodynamic properties drastically. This finding may have implications on other studies of atomic clusters.

A 19.3 Thu 11:15 BAR 205

Dynamical structure factor of extended nano plasmas — •Thomas Raitza, Heidi Reinholz, and Gerd Röpke — Universität Rostock

The dynamical structure factor of bulk plasmas is related to correlation functions, see [1]. Clusters of solid state densities can form nano plasmas after laser irradiation with intensities of $10^{13} - 10^{16}$ W·cm^{-2}, which were investigated via molecular dynamics (MD) simulations. Free cluster electrons relax within a few femto seconds into a local thermodynamic equilibrium (LTE) in [2]. A *restricted MD simulations* scheme for finite systems has been developed in [3]. The generalization of the dynamical structure factor via bi-local current-density correlation function is introduced. Investigations of dynamical correlations via *restricted MD simulations* are presented for 1D chains [4] and 3D clusters. Several excitation modes were found and characterized. Dispersion relations for resonance frequencies were investigated with focus on cluster size dependency. In particular, the role of collisions on resonance damping will be presented.

[1] H. Reinholz; *Ann. Phys. Fr.* **30**, N° 4 - 5 (2006).
[2] T. Raitza, H. Reinholz, G. Röpke, I. Morozov, and E. Suraud; *Contrib. Plasma Phys.* **49**, 498 (2009).
[3] T. Raitza, H. Reinholz, G. Röpke, and I. Morozov; *J. Phys. A* **42**, 214048 (2009).
[4] T. Raitza, H. Reinholz, and G. Röpke; *Int. J. Mod. Phys. B*, accepted (2010).

A 19.4 Thu 11:30 BAR 205

Velocity-Map-Imaging Spectroscopy of Alkali Metals Embedded Inside Helium Nanodroplets — •Lutz Fechner, Marcel Mudrich, and Frank Stienkemeier — Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany

Helium nanodroplets provide an 'ideal' matrix for spectroscopy of embedded molecules due to the low temperature conditions (400 mK) and extremely weak guest-host interactions. However, photoionization spectroscopy has mostly been hampered by the trapping of photoions in 'snowballs' that remain bound to the droplets which prevents efficient ion detection. Therefore, a new velocity-map-imaging spectrometer for photo-electrons has been built and characterized. In first experiments rubidium atoms are studied in a resonance-enhanced-multiphoton-ionization (REMPI) scheme by means of electron as well as ion imaging-spectroscopy. Gas-phase measurements are compared to spectra obtained with atoms attached to the surface of helium nanodroplets. These measurements pave the ground for future femtosecond photoionization studies of molecules embedded inside helium nanodroplets.

A 19.5 Thu 11:45 BAR 205

Ionization dynamics of doped helium nanodroplets in intense few-cycle IR laser fields — •Siva Rama Krishnan[1], Marcel Mudrich[2], Lutz Fechner[2], Vandana Sharma[1], Manuel Kremer[1], Bettina Fischer[1], Nicolas Camus[1], Jagannath Jha[3], Krishnamurthy Manchikanti[3], Robert Moshammer[1], Frank Stienkemeier[2], and Joachim Ullrich[1] — [1]Max Planck Institut für Kernphysik, Saupferchekweg 1, 69117 Heidelberg, Germany — [2]Physikalisches Institut, Universität Freiburg Hermann-Herder-Str. 3, 79104 Freiburg, Germany — [3]Tata Institute of Fundamental Research, 1 Homi Bhabha Road, Mumbai 400005, India

The ionization dynamics of two-component rare-gas clusters in intense laser fields has evoked recent interest due to the markedly different behaviour when compared to pristine clusters both in the intense IR [1,2] and intense VUV or soft X-ray domains [3,4]. We present studies on the ionization dynamics of helium nanodroplets (10^4 He atoms/droplet) doped with 1-100 atoms of other rare-gas dopants (Xe, Kr or Ar) which form embedded clusters at the center of the helium droplet. Intense few-cycle laser pulses (6 fs) with a central wavelength of 790nm and peak intensities in the range of 10^{14-15} W.cm^{-2} were used to ionize these droplets. Our studies reveal that the resulting ionization dynamics is very sensitive to the number of dopants in the droplets. [1]J. Jha and M. Krishnamurthy, J. Phys. B 41, 041002 (2008) [2]A. Mikaberidze et al., Phys. Rev. Lett. 102, 128102 (2009) [3]H. Thomas et al.,J. Phys. B. 42, 134018 (2009) [4]C. Gnodtke et al., Phys. Rev. A 79, 041201 (2009).

A 19.6 Thu 12:00 BAR 205

Rare-gas clusters in intense VUV, XUV and soft x-ray pulses: Signatures of the transition from nanoplasma-driven cluster expansion to Coulomb explosion in ion and electron spectra — •Mathias Arbeiter and Thomas Fennel — Institute of Physics, University of Rostock

We investigate the wavelength dependent ionization, heating, and expansion dynamics of medium-sized rare-gas clusters (Ar_N) under intense femtosecond short-wavelength free electron laser pulses by quasi-classical molecular dynamics simulations. A comparison of the interaction dynamics for pulses with $\hbar\omega$=20, 38, and 90 eV photon energy at fixed total excitation energy indicates a smooth transition from plasma-driven cluster expansion, where predominantly surface ions are expelled by hydrodynamic forces, to quasi-electrostatic behavior with almost pure Coulomb explosion[1]. Corresponding signatures in the time-dependent cluster dynamics as well as in the final ion and electron spectra support that this transition is linked to a crossover in the electron emission processes. This would be of interest for applications that are closely related to the correlation between ionization and expansion dynamics of many-particle systems in intense FEL pulses, such as single-shot diffractive imaging or time resolved x-ray holography.

[1] M. Arbeiter, Th. Fennel, submitted 2010

A 19.7 Thu 12:15 BAR 205

Resonant charging of Xe clusters in Helium nanodroplets under intense laser fields — •Christian Peltz and Thomas Fennel — Institute of Physics, University of Rostock, Germany

When exposed to intense laser fields, mixed clusters in core-shell configuration are expected to show multiple plasmon resonances[1]. There is an ongoing debate on the resulting signatures in the final emission spectra of ions and electrons. To study the microscopic interaction dynamics, we theoretically investigate Xe clusters embedded in He nanodroplets under pump-probe laser excitation ($\tau = 25$ fs, $I_0 = 2.5 \times 10^{14}$W/cm^2, $\lambda = 800$ nm). Our molecular dynamics simulations on $Xe_{309}He_{10000}$ and comparison to simulation results for free Xe_{309} give evidence for the presence of selective resonance heating in the He shell and the Xe cluster, while a corresponding double hump feature in the final Xe charge spectra is absent. The pump-probe dynamics of the Xe spectra from the embedded system is qualitatively similar to that of the free species. In strong contrast to that, the predicted electron spectra do show well-separated and pronounced features from highly efficient plasmon assisted electron acceleration for both resonances in the embedded clusters. A detailed analysis of the ionization and recombination dynamics explains the apparent discaccord between the resonance features in ion and electron spectra[2].

[1] A. Mikaberidze et al. , Phys. Rev. A **77**, 041201 (2008)
[2] Ch. Peltz and Th. Fennel, arXiv:1009.4546v1

A 19.8 Thu 12:30 BAR 205

Condensation properties of single clusters under extreme conditions — •Marcus Adolph[1], Daniela Rupp[1], Tais Gorkhover[1], Sebastian Schorb[1], Heiko Thomas[1], David Wolter[1], Robert Hartmann[2], Nils Kimmel[2], Christian Reich[2], Rolf Treusch[3], Thomas Möller[1], and Christoph Bostedt[4] — [1]IOAP/TU-Berlin, Berlin, Germany — [2]MPG-HLL, München, Germany — [3]DESY, Hamburg, Germany — [4]SLAC, Palo Alto, USA

Free Electron Lasers (FEL) produce high energy XUV pulses and offer a new tool for exploring ultrafast motions in molecular systems and condensed matter. Currently a fast development of FELs towards shorter wavelength and higher pulse energies is taking place. The Free Electron Laser in Hamburg (FLASH) has been extended to seeded lasing and facilities in USA (LCLS) and Japan (Spring8) came into operation.

Using the short wavelength and high power densities of the FEL, we performed the first imaging experiments on single nanometer size rare gas clusters. This technique helps to gain insight into the basic interaction between FEL XUV radiation and matter which is especially important with regard to the imaging of bio molecules. The scattering images also allows us to reconstruct the size of free single clusters in the gas phase. This was used to study the process of clustering of single particles on a single shot basis. We observed the condensation characteristics of Xenon gas and growing processes of Xenon clusters under extreme pressure conditions, close to the vapor pressure curve.

A 19.9 Thu 12:45 BAR 205

X-ray and VUV Absorption Spectroscopy on Size Selected Chromium and Copper Clusters — •Felix Ameseder[2], Christof Ebrecht[2], Konstantin Hirsch[2], Christian Kasigkeit[2], Andreas Langenberg[1], Markus Niemeyer[2], Jochen

Rittmann[1], Vicente Zamudio-Bayer[1], Marlene Vogel[1], Bernd von Issendorff[3], Thomas Möller[2], and Tobias Lau[1] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie, Institut für Methoden und Instrumentierung der Synchrotronstrahlung, Albert-Einstein-Straße, D-12489 Berlin — [2]Technische Universität Berlin, Institut für Optik und Atomare Physik, EW 3-1, Hardenbergstraße 36, D-10623 Berlin — [3]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg

Studies on clusters reveal important information, including changes of the electronic structure from atomic to bulk like properties with increasing cluster size. Here we present the first X-ray and VUV absorption spectra on free size selected chromium and copper clusters. The clusters 2nd ionization potentials were determined from photoionization efficiciency curves. According to the Liquid Drop Model (LDM) a metal cluster can be described as a metallic sphere and thus its ionization potential scales linearly with cluster size over the inverse cluster radius. The results of 3d/4s valence and 2p core level photoionization will be discussed. By comparing the size dependence of the ionization potential derived from valence and core level photoionization insight into the effects of charging energy according to the LDM as well as shifts of electronic level of transition metal clusters can be obtained.

A 20: Ultra-cold atoms, ions and BEC V (with Q)

Time: Thursday 10:30–13:00 Location: BAR 106

A 20.1 Thu 10:30 BAR 106

Supersolid Phase of Cold Fermionic Polar Molecules in 2D Optical Lattices — •Liang He and Walter Hofstetter — Institut für Theoretische Physik, Johann Wolfgang Goethe–Universität, 60438 Frankfurt/Main, Germany

The recent successful realization of a degenerate quantum gas of fermionic polar molecules of ^{40}K^{87}Rb [1] opens the door towards exploring the interesting many-body physics originating from the dipole-dipole interactions in fermionic systems. Here we investigate a system of ultra-cold fermionic polar molecules in a two-dimensional square lattice interacting via both the long-ranged dipole-dipole interaction and the short-ranged on-site attractive interaction. Singlet superfluid, charge density wave, and supersolid phases are found to exist in the system. We map out the zero temperature phase diagram and find that the supersolid phase is considerably stabilized by the dipole-dipole interaction and can thus exist over a large region of filling factors. At finite temperatures, we study the melting of the supersolid with increasing temperature, map out a finite temperature phase diagram of the system at a fixed filling factor, and determine the parameter region where the supersolid phase can be possibly observed in experiments.

[1] K.-K. Ni, S. Ospelkaus, M. H. G. de Miranda, A. Pe'er, B. Neyenhuis, J. J. Zirbel, S. Kotochigova, P. S. Julienne, D. S. Jin, and J. Ye, Science, **322**, 231 (2008).

A 20.2 Thu 10:45 BAR 106

Fermi-Hubbard physics with ultracold fermions in optical lattices — •Daniel Greif, Leticia Tarruell, Thomas Uehlinger, Gregor Jotzu, and Tilman Esslinger — Institute for Quantum Electronics, ETH Zurich, Switzerland

The Fermi-Hubbard Hamiltonian is one of the key models for strongly correlated electrons in solid state systems and incorporates fascinating phenomena such as Mott-insulating behavior or spin ordered phases. Despite intense numerical effort, a number of questions still remains open, in particular on the low temperature phases where spin degrees of freedom start to play a role.

In our experiment we use a two-component Fermi gas loaded into an optical lattice to realize this simple model Hamiltonian. Currently several experiments are reaching out to access the regime of quantum magnetism. We report on recent progress of creation and characterization of low entropy states in the lattice.

A 20.3 Thu 11:00 BAR 106

Generalized Hartree-Fock Theory for Interacting Fermions in Lattices: Numerical Methods — •Christina Kraus and Ignacio Cirac — Max-Planck Institut für Quantenoptik, Garching

We present numerical methods to solve the Generalized Hartree-Fock theory for fermionic systems in lattices, both in thermal equilibrium and out of equilibrium. Specifically, we show how to determine the covariance matrix corresponding to the Fermionic Gaussian state that optimally approximates the quantum state of the fermions. The methods apply to relatively large systems, since their complexity only scales quadratically with the number of lattice sites. Moreover, they are specially suited to describe inhomogenous systems, as those typically found in recent experiments with atoms in optical lattices, at least in the weak interaction regime. As a benchmark, we have applied them to the two-dimensional Hubbard model on a 10x10 lattice with and without an external confinement.

A 20.4 Thu 11:15 BAR 106

Quantum-noise quenching in quantum tweezers — •Stefano Zippilli[1,2,3], Bernd Mohring[4], Eric Lutz[5], Giovanna Morigi[1,2], and Wolfgang Schleich[4] — [1]Departament de Física, Universitat Autònoma de Barcelona, E-08193 Bellaterra, Spain — [2]Theoretische Physik, Universität des Saarlandes, D-66041 Saarbrücken, Germany — [3]Fachbereich Physik and research center OPTIMAS, Technische Universität Kaiserslautern, D-67663 Kaiserslautern, Germany — [4]Institut für Quantenphysik, Universität Ulm, D-89081 Ulm, Germany — [5]Department of Physics, University of Augsburg, D-86135 Augsburg, Germany

The efficiency of extracting single atoms or molecules from an ultracold bosonic reservoir is theoretically investigated for a protocol based on lasers, coupling the hyperfine state in which the atoms form a condensate to another stable state, in which the atom experiences a tight potential in the regime of collisional blockade, the quantum tweezers. The transfer efficiency into the single-atom ground state of the tight trap is fundamentally limited by the collective modes of the condensate, which are thermally and dynamically excited and constitute the ultimate noise sources. This quantum noise can be quenched for sufficiently long laser pulses, thereby achieving high efficiencies, and showing that this protocol can be applied for quantum information processing based on tweezer traps for neutral atoms.

A 20.5 Thu 11:30 BAR 106

Definite angular momentum and fragmentation in 3D attractive BECs — •Marios C. Tsatsos[1], Alexej I. Streltsov[1], Ofir E. Alon[1,2], and Lorenz S. Cederbaum[1] — [1]Theoretische Chemie, Physikalisch-Chemisches Institut, Universität Heidelberg, Im Neuenheimer Feld 229, D-69120 Heidelberg, Germany — [2]Department of Physics, University of Haifa at Oranim, Tivon 36006, Israel

We consider a 3D Bose-Einstein Condensate (BEC), with attractive interparticle interactions, embedded in a harmonic, spherically symmetric trap. This system is metastable only if the total number of bosons N and the interaction strength λ_0 do not exceed some critical values. Otherwise the system collapses. The Gross-Pitaevskii (GP) theory predicts the maximum (critical) number of bosons N_{cr}^{GP} that, for a given λ_0, can be loaded to the ground state of the system, without its collapse. But, what happens to the excited states? To investigate the structure and stability of these states we must go beyond GP theory; the excited states have definite values of angular momentum L, are highly fragmented and can support number of bosons much greater than N_{cr}^{GP}.

A 20.6 Thu 11:45 BAR 106

Continuous Loading of a Conservative Trap from an Atomic Beam — •Markus Falkenau[1], Valentin Volchkov[1], Jahn Rührig[1], Axel Griesmaier[1,2], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Germany — [2]Niels-Bohr Insitute, Copenhagen, Denmark

We present results on the fast accumulation of ^{52}Cr atoms in a conservative potential from a magnetically guided atomic beam. Without laser cooling on a cycling transition, a single dissipative step realized by optical pumping allows to load atoms at a rate of $2 \cdot 10^7 s^{-1}$ in the trap. Within less than 100 ms we reach the collisionally dense regime, from which we directly produce a Bose-Einstein condensate with subsequent evaporative cooling. This constitutes a new approach to degeneracy where, provided a slow beam of particles can be produced by some means, Bose-Einstein condensation can be reached for species without a cycling transition.

A 20.7 Thu 12:00 BAR 106

Novel magnetic trap design for ultra-cold metastable helium atoms with large optical access — •Franz Sievers, Juliette Simonet, Sanjukta Roy, Jérôme Beugnon, Michèle Leduc, and Claude Cohen-Tannoudji — Laboratoire Kastler Brossel, École Normale Supérieure, 24 rue Lhomond, 75231 Paris, France

We present the design of a modified Cloverleaf-type Ioffe-Pritchard trap for Bose-Einstein condensation of ultra-cold atoms, compatible with in situ loading of the condensed gas into a three-dimensional optical lattice. The coil geometry offers optical access for three independent triplets of orthogonal laser beams that cross in the centre of the trap. Two are used for the magneto-optical trap and the projected three-dimensional optical lattice, respectively. Technical considerations of the trap design, as well as the electric circuitry for fast switching are reviewed. This set-up is intended to operate for metastable helium, but is also of practical interest for experiments with other species.

A 20.8 Thu 12:15 BAR 106

Gauge fields for ultra-cold Ytterbium atoms — •Sebastian Krinner[1,2], Fabrice Gerbier[1], Jerôme Beugnon[1], and Jean Dalibard[1] — [1]Laboratoire Kastler Brossel, 24 rue Lhomond, 75005 Paris, France — [2]Institute for Quantum Electronics, ETH Zürich, Hönggerberg, CH-8093 Zürich, Switzerland

Cold atoms in optical lattices can serve as model systems for condensed matter physics. In our project we plan to investigate the rich physics of fractional quantum Hall phases. I will first briefly explain the core of the planned experiment, i.e. the implementation of a strong U(1)-like gauge field on cold Ytterbium atoms confined in a two-dimensional square lattice.

The second part focuses on the laser cooling of Yb. It consists of Zeeman slowing of an atomic beam using the strong singlet transition at 399nm and subsequent magneto-optical trapping using the green intercombination line at 556nm. Both laser wavelengths are produced via the technique of second-harmonic generation. As a showcase I will treat the generation of the 556nm light relying on intra-cavity frequency doubling of a 2W fiber laser at 1112nm. The output power of 1.2W corresponds to 80% efficiency and suggests an alternative to dye lasers.

A 20.9 Thu 12:30 BAR 106

Radiofrequency spectroscopy of a strongly interacting two-dimensional Fermi gas — •Bernd Fröhlich, Michael Feld, Enrico Vogt, Marco Koschorreck, and Michael Köhl — Cavendish Laboratory, University of Cambridge, JJ Thomson Avenue, Cambridge CB3 0HE

We have realized and studied a strongly interacting two-component atomic Fermi gas confined to two spatial dimensions using an optical lattice. Using radio-frequency spectroscopy we measure the interaction energy of the gas. We find that the strong confinement to two dimensions induces scattering resonances and leads to the existence of confinement-induced molecules which have no counterpart in three dimensions.

A 20.10 Thu 12:45 BAR 106

Large coordination number expansion for a lattice Bose gas — •Patrick Navez[1], Ralf Schützhold[2], and Konstantin Krutitsky[2] — [1]Institut für Theoretische Physik, TU Dresden, D-01062 Dresden, Germany — [2]Fakultät für Physik, Universität Duisburg-Essen, Lotharstrasse 1, D-47057 Duisburg, Germany

We establish a set of hierarchy equations describing the time evolution of the N-points spatial correlation reduced density matrix in a lattice Bose gas. This set of equations is solved through a 1/z expansion where z is the coordination number i.e. number of interaction of a site with its nearest neighbors. The leading order of this expansion corresponds to the time-dependent Gutzwiller mean field approach that is used to describe the Bragg scattering in the superfluid regime. The next order contribution includes the correlations between sites. We illustrate how these correlations appear in the process of a ultra fast sweeping from a deep Mott regime to the superfluid regime.

A 21: Atomic systems in external fields II

Time: Thursday 14:00–16:00 Location: BAR 205

A 21.1 Thu 14:00 BAR 205

Development of a Magnetically Shielded Compact ^{3}He Polarizer — •Oliver Endner, Christopher Hauke, Werner Heil, Sergei Karpuk, Jan Klemmer, Christian Mrozik, and Ernst-Wilhelm Otten — Institut für Physik, Johannes Gutenberg-Universität, Mainz

The method of polarizing ^{3}He via metastability exchange optical pumping is well known since the early 1960s. Since then hyperpolarized gases have found manifold applications in fundamental science as well as in medical research. The present polarizer apparatus in Mainz used as central facility is well established and can produce up to three standard liters of gas per hour with a polarization of 60–65 %, sufficient for medical applications. For basic research where higher degrees of polarization are needed one can reach up to 78 % at a production rate of one standard liter per hour. To provide the users with high polarization degrees and big amounts of polarized gas a compact apparatus was designed. Using this compact polarizer as local polarizing facility enables the users to avoid polarization losses during shipping. For the new polarizer several concepts had to be developed to minimize the size while retaining the production rate and polarization degree. There have been efforts in optimizing optics, polarization conserving compression of the gas and homogenization of the magnetic field. By using a closed cylinder of soft magnetic material a relative field gradient of better than $\Delta B/B < 3.8 \cdot 10^{-4}\,\mathrm{cm}^{-1}$ has been obtained, which is needed to have the desired gradient relaxation time for sufficient polarization. Further results will be presented in this talk.

A 21.2 Thu 14:15 BAR 205

Long-lived resonance states in planar helium — Celsus Bouri[1,2], Johannes Eiglsperger[3], Javier Madronero[3,4], Felix Joerder[1], •Pierre Lugan[1], Vera Neimanns[1], Klaus Zimmermann[1], and Andreas Buchleitner[1] — [1]Physics Department, University of Freiburg, Germany — [2]CEPAMOQ, Universite de Douala, Cameroon — [3]Physics Department, TU Munich, Germany — [4]PAMO, Universite catholique de Louvain, Louvain la Neuve, Belgium

Doubly excited states of helium ionize because of the Coulomb interaction between the two electrons of the atom and the formation of resonance states. Long-lived resonance states have been identified in the form of so called frozen planet states [1], i.e. collinear configurations of the electrons and the nucleus, with zero angular momentum, which exhibit a remarkable stability. We report here on the identification of analogous long-lived resonance states for non-vanishing angular momentum, and on the characterization of electronic correlations in these states. The ionization of the latter is analyzed on the basis of partial decay rates extracted from complex dilation.

[1] K. Richter and D. Wintgen, J. Phys. B 23, L197 (1990).

A 21.3 Thu 14:30 BAR 205

Single Atom Interferometer with Spatial Separation — •Andreas Steffen, Noomen Belmechri, Michal Karski, Kohei Katayama, Sebastian Hild, Andrea Alberti, Wolfgang Alt, Artur Widera, and Dieter Meschede — Institut für angewandte Physik, Universität Bonn

We demonstrate a single atom interferometer (SAI) consisting of a Cs atom being split by multiple sites in a 1D optical lattice. State-dependent dipole potentials controlled by the lattice polarization allow coherent division and recombination over up to 11 sites. The two spatially separated states of the SAI accumulate phase from spatial potential differences, making the SAI sensitive to magnetic field gradients or acceleration. We have characterized the phase stability of the interferometer and its sensitivity to potential gradients. In the future, collisional phases and two-atom entanglement shall be measured using this setup.

A 21.4 Thu 14:45 BAR 205

Numerical solution of coupled radial ODE eigenvalue problems — •Robert Hammerling[1] and Othmar Koch[2] — [1]Center Computational Material Science, TU Wien, A-1040, AUT — [2]Institute for Analysis, TU Wien, A-1040, AUT

In the effective one-particle description of electronic structure within DFT one has to calculate eigenvalues of PDE Schrödinger operators. For deep lying core states normally only the local radial potential is used and therefore decoupled ODEs can be solved. In this contribution we present our non-perturbative approach (see e.g. Computer Physics Communications, 181, 1557) to the coupled radial equations in a non-spherical potential. We compare a few different solution methods, one-sided matrix shooting, two-sided matrix shooting, polynomial collocation strategies and basis set expansion methods. The studied test cases comprise the Hydrogen molecular ion treated in one-center approximation and the dc-Stark effect of the Hydrogen atom.

The work is part of a joint collaboration between mathematicians and physicists within the project 'Mathematik und .. 2007' sponsored by WWTF.

A 21.5 Thu 15:00 BAR 205

3D ground state cooling in a doughnut-shaped optical trap — •Sebastian Hild, Andrea Alberti, Wolfgang Alt, Noomen Belmechri, Michal Karski, Kohei Katayama, Arif Mawardi, Andreas Steffen, Artur Widera, and Dieter Meschede — Institut für Angewandte Physik der Universität Bonn, Germany

We report on our approach to 3D ground state cooling in a state-selective 1D optical lattice potential, paving the way to create entanglement via controlled cold collisions. Due to weak transversal confinement in the 1D standing wave the Lamb-Dicke regime can only be reached in the axial direction. By superposing a blue detuned doughnut shaped beam, the trap frequencies in the radial direction can be increased significantly. Raman lasers will then be used to reach the vibrational ground state. This will also allow us to prepare Cs atoms in their motional ground state. Increased coherence times open the perspective to extend the prior work, such as quantum walks, to new regimes of unprecented quantum control over single neutral atoms.

A 21.6 Thu 15:15 BAR 205

Nuclear spin-dependent parity-violation asymmetry in hyperfine transitions in He-like ions — •Fabrizio Ferro[1,2], Andrey Surzhykov[1,2], and Thomas Stöhlker[1,2,3] — [1]Physikalisches Institut, Universität Heidelberg, Germany — [2]GSI-Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany — [3]Helmholtz-Institut Jena, Germany

Parity-violation (PV) in atomic systems offers a unique possibility to test the electroweak theory at very low energies. In atoms with non-zero nuclear spin, $I \neq 0$, the nuclear parity-violating anapole moment interacts magnetically with electrons. This leads to the appearance of parity-forbidden electromagnetic transitions between atomic levels. Recent efforts have been targeted at measuring the anapole moment in neutral atoms. Instead, we propose an alternative way, by employing He-like ions as available at storage ring facilities (e.g. ESR-GSI), and taking advantage of the precision spectroscopy techniques available for highly-charged ions. We show that by stimulating the transition between the hyperfine levels $(1s2s)\,^1S_0$ $(F = I)$ and $(1s2s)\,^3S_1$ $(F' = I-1, I, I+1)$ with circularly-polarized laser light, an interference term between the allowed M1 multipole and the E1 parity-violating multipole may be observed in the cross section. By performing this experiment with ions in the range $28 \leq Z \leq 35$ alternatively with left- and right-polarized light, an asymmetry of order 10^{-7} in the cross section is expected. In the last part of the talk, we discuss the key experimental requirements for such a measurement, and show how the asymmetry directly relates to the nuclear weak charge.

A 21.7 Thu 15:30 BAR 205

Quantum simulations of coupled electronic and nuclear fluxes in molecules — •Anatole Kenfack[1], Ingo Barth[2], Hans-Christian Hege[3], Michael Koppitz[3], Caroline Lasser[4], Joern Manz[1], Falko Marquardt[3], Guennaddi Paramonov[1], and Beate Paulus[1] — [1]Institut für Chemie und Biochemie, FU Berlin, Takustr.3, 14195 Berlin — [2]Max-Born Institut, Max-Born-Str. 2A, 12489 Berlin — [3]Zuse Institut Berlin, Takustr.7, 14195 Berlin — [4]Zentrum Mathematik, TU München, 85747 Garching

To compute electronic and the nuclear fluxes in molecules, a Born-Oppenheimer (BO) based method has recently been developed [1]. This approach is promising for large molecules since the non-BO is restricted to 3-body problem[2,3]. For a vibrating H_2^+, novel effects have been discovered. As an example, there are attoseconds intervals where the electron does not adapt to the nuclear motion. The visualization of the associated densities and fluxes supports the present analysis. The initial state preparation also matters and yields significant deviations[4]. Interesting departures have been revealed with isotopes of H_2^+: the heavier the isotope, the larger the flux, the smaller the dispersion, and the longer the revival period. These results are partly explained analytically. The mechanism of few observables remains subtle as the result of quantum interference [5]. [1] I. Barth et al. CPL 481, 118 (2009). [2] Chelkowsky et al. PRA 52, 2977 (1995) [3] F. Martin et al. Science 315, 629 (2007) [4] A. Kenfack et al. PRA 81, 052502 (2010) [5] A. Kenfack et al. (2010), PRA (2010) in press.

A 21.8 Thu 15:45 BAR 205

Partial Decay Rates in Driven One Dimensional Helium — Celsus Bouri[1,2], Felix Jörder[1], Pierre Lugan[1], Vera Neimanns[1], Sören Roerden[1], •Klaus Zimmermann[1], and Andreas Buchleitner[1] — [1]Albert-Ludwigs University of Freiburg — [2]University of Douala, Cameroon

The continous part of the spectrum of one dimensional driven Helium below the double ionization threshold is structured by resonances, that play a vital role in its decay.

We employ the method of complex dilation to resolve the decay from a given initial state into channels, distinguishing between single and double ionization. By means of Floquet theory we tell processes with different numbers of photons involved apart.

A 22: Electron scattering and recombination I

Time: Thursday 14:00–16:00 Location: BAR 106

Invited Talk A 22.1 Thu 14:00 BAR 106

Influence of two-center electronic correlations on atomic processes — •Carsten Müller, Alexander B. Voitkiv, Bennaceur Najjari, Jose R. Crespo Lopez-Urrutia, and Zoltan Harman — Max-Planck-Institut für Kernphysik, Heidelberg

When an atom is not isolated in space but close to another atom, the electronic structures at the two centers can be coupled by long-range electromagnetic interactions causing a variety of interesting phenomena. In particular, electron-ion recombination may proceed resonantly via excitation of an electron in a neighboring atom, which subsequently deexcites by photo-emission [1]. Using examples from different fields of physics, we demonstrate that this two-center dielectronic process can largely dominate over single-center radiative recombination at interatomic distances as large as several nanometers.

The corresponding time-reversed process is two-center resonant photo-ionization, where one of the reaction pathways for ionization is radiationless transfer of excitation from a neighboring atom (so-called interatomic Coulombic decay). Characteristic features are shown to arise in this process, both in its temporal development and the spectrum of emitted electrons [2].

[1] C. Müller, A.B. Voitkiv, J.R. Crespo López-Urrutia, Z. Harman, Phys. Rev. Lett. 104, 233202 (2010)

[2] B. Najjari, A.B. Voitkiv, C. Müller, Phys. Rev. Lett. 105, 153002 (2010)

A 22.2 Thu 14:30 BAR 106

Spin dynamics of electrons in strong fields studied via bremsstrahlung from a polarized electron beam — •Stanislav Tashenov[1,2,3], Torbjörn Bäck[1], Roman Barday[4], Bo Cederwall[1], Joachim Enders[4], Anton Khaplanov[1], Yuliya Poltoratska[4], Kai-Uwe Schässburger[1], and Andrey Surzhykov[3,5] — [1]Royal Institute of Technology, Stockholm, Sweden — [2]Stockholm University, Sweden — [3]Physikalisches Institut der Universität Heidelberg, Germany — [4]Institut für Kernphysik, Tech-

nische Universität Darmstadt, Germany — [5]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

Linear polarization of the photons emitted in the process of the atomic field electron bremsstrahlung has been studied at the newly developed 100 keV polarized electron source of TU Darmstadt. A correlation between the initial orientation of the electron spin and the degree and the angle of photon linear polarization has been measured for the first time. For this purpose a hard x-ray Compton polarimeter consisting of a segmented high purity germanium detector and an external passive photon scattering target have been applied. Linear polarization sensitive Compton and Rayleigh photon scattering distributions have been sampled by the segmented detector. The observed polarization correlation reveals a precession of the electron spin as it moves in the field of the nucleus. The full-relativistic calculations for the case of radiative recombination into a Rydberg series limit have been corroborated by the measurement. The results of this experiment suggest a new method for electron beam polarimetry.

A 22.3 Thu 14:45 BAR 106

Dielectronic recombination involving two atomic centers — •Carsten Müller, Alexander B. Voitkiv, Jose R. Crespo Lopez-Urrutia, and Zoltan Harman — Max-Planck-Institut für Kernphysik, Heidelberg

In the presence of a neighboring atom, electron-ion recombination can proceed resonantly via excitation of an electron in the atom, which subsequently deexcites by photoemission. Using examples from different fields of physics, we demonstrate that this two-center dielectronic process can largely dominate over single-center radiative recombination at interatomic distances as large as several nanometers [1].

[1] C. Müller, A.B. Voitkiv, J.R. Crespo López-Urrutia, Z. Harman, Phys. Rev. Lett. 104, 233202 (2010)

A 22.4 Thu 15:00 BAR 106

Electron impact excitation of highly-charged ions — •Lalita Sharma[1,2], Andrey Surzhykov[1,2], Rajesh Srivastava[3], and Stephan Fritzsche[2,4] — [1]Physikalisches Institut der Universität Heidelberg — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH — [3]Indian Institute of Technology Roorkee, India — [4]Department of Physical Sciences, University of Oulu, Finland

During the last decade, electron impact excitation of few–electron ions has been explored intensively both at electron beam ion traps (EBIT) and ion storage ring facilities. In these studies, particular attention has been paid to the linear polarization of the subsequent characteristic photon emission. Such a (fluorescence) polarization can be used as a precise tool for the plasma diagnostic as well as for better understanding of the relativistic and many–body effects in electron-ion collisions. In this contribution, a fully–relativistic distorted–wave code was developed by us recently, and has been employed to investigate electron impact excitation of highly charged ions. Detailed calculations have been performed, in particular, for the $K \to L$ excitation of hydrogen–like Ar^{17+}, Ti^{21+} and Fe^{25+} ions for a wide range of collision energies. Apart from the total cross sections theoretical predictions were obtained for the alignment parameters of the excited ionic states and, hence, for the polarization of the characteristic Lyman–α lines. Results of our calculations are compared with the available experimental and theoretical data.

A 22.5 Thu 15:15 BAR 106

Bestimmung von Elektronenstoßionisationsquerschnitten hochgeladener Eisenionen über Ionenextraktionsmessungen an einer EBIS — •Robert Mertzig[1], Alexandra Thorn[1], Falk Ullmann[2] und Günter Zschornack[1] — [1]Institut für Festkörperphysik, Technische Universität Dresden, Germany — [2]Dreebit GmbH, Dresden, Germany

EBIS (Electron Beam Ion Source) - Ionenquellen bieten hervorragende Voraussetzungen, Atomdaten von hochgeladenen Ionen experimentell zu bestimmen. Der Beitrag beschäftigt sich mit der Bestimmung von Elektronenstoßionisationsquerschnitten für die Ionisation von Eisenionen bis hin zu Fe^{23+} im Elektronenenergiebereich von 15keV bis 20keV. Derartige Atomdaten sind z.B. für die Astrophysik und für die Verifizierung von theoretischen Ansätzen zur Beschreibung der Elektronenstoßionisation von Interesse. Zur Bestimmung der Ionisationsquerschnitte erfolgten Messungen der extrahierten Teilchenzahlen für individuelle Ionenladungszustände als Funktion der Ionisationszeit in einer EBIS-Ionenquelle des Typs Dresden EBIS-A. Aus dem zeitlichen Intensitätsverlauf für Ionenströme der vermessenen Ionenladungszustände bei verschiedenen Ionisationszeiten lassen sich Wirkungsquerschnitte für die Elektronenstoßionisation von Eisenionen bestimmen. Die Ergebnisse werden vorgestellt, mit gängigen Theorien verglichen und diskutiert. Über die Messung der Querschnitte für Eisenionen hinaus wird demonstriert, dass die verwendete Methodik geeignet ist, Elektronenstoßionisationsquerschnitte für unterschiedlichste Ionen über einen weiten Ladungsbereich zu vermessen.

A 22.6 Thu 15:30 BAR 106

Electron Impact Ionization of Small Rare Gas Clusters — •Thomas Pflüger, Xueguang Ren, Alexander Dorn, and Joachim Ullrich — Max-Planck-Institut für Kernpysik

Atomic and molecular clusters present an excellent field of investigation bridging the gap between sole constituents and macroscopic matter. Therefore, structural as well as dynamical information can contribute to the understanding of more complex systems. Kinematically complete electron impact ionization experiments at projectile energies below 100 eV were performed and differential cross sections for various kinematics could be obtained. A highly efficient advanced reaction microscope (RM) was used to detect all charged final state particles over almost the complete solid angle. The selected targets were small Argon and Neon clusters where a variety of reaction channels could be explored. The ion signals show no indication for a direct creation of a respective cluster ion with a size larger than two. Due to the selected kinematic conditions a strong involvement of the residual ionic potential in the scattering process was forced and, therefore, structural differences of the target can result in diverse scattering dynamics. Focusing on the direct single ionization of the dimer, three-fold differential 3D cross sections will be presented. They reveal enhanced out-of-plane intensities with dramatically different features over the respective atomic data.

A 22.7 Thu 15:45 BAR 106

Multiple resonances in nuclei coupling to the atomic shells — Srinivas K. Arigapudi[1,2] and •Adriana Pálffy[2] — [1]Indian Institute of Technology Delhi, New Delhi, India — [2]Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Processes at the borderline between atomic and nuclear physics open the possibility to explore properties of exotic nuclei via experiments involving highly charged ions [1]. Among these, nuclear excitation by electron capture (NEEC) [2] or nuclear excitation by electron transition (NEET) [3] are coupling nuclei to the atomic shells. In the doubly resonant process of NEET, the decay of a bound electron into a lower atomic shell leads to the excitation of the nucleus [3]. This process requires on the one hand the overlap of an atomic and nuclear resonance and on the other hand the presence of an appropriate atomic hole. Due to its resonant character, NEET can be more efficient than NEEC as nuclear excitation mechanism.

Here we investigate a scenario in which the dielectronic recombination of a free electron into a highly charged ion creates the initial hole necessary for NEET. This multiply resonant process is quite efficient not last due to the interferences that may occur involving electron recombination mechanisms and radiative electronic and nuclear transitions. The consequences of this process on nuclear state population in dense plasma environments are discussed.

[1] A. Pálffy, Contemporary Phys. 51, 471 (2010)
[2] A. Pálffy, W. Scheid, Z. Harman, Phys. Rev. A 73, 012715 (2006)
[3] S. Kishimoto *et al.*, Phys. Rev. Lett. 85, 1831 (2000)

A 23: Ultracold Atoms: Trapping and Cooling 1 (with Q)

Time: Thursday 14:30–16:00 Location: SCH A118

A 23.1 Thu 14:30 SCH A118

Experiments on atoms trapped in a two-color-dipole trap — •Rudolf Mitsch[1], Daniel Reitz[1], Melanie Müller[1], Samuel T. Dawkins[2], and Arno Rauschenbeutel[1] — [1]Technische Universität Wien - Atominstitut, Stadionallee 2, A-1020 Wien — [2]Johannes Gutenberg-Universität Mainz, AG QUANTUM, D-55099 Mainz

Our recent results on trapping laser-cooled cesium atoms around a subwavelength-diameter optical nanofiber will be presented. The atoms are localized in a dipole trap formed by a two-color evanescent field surrounding the optical nanofiber. The atoms are detected by sending a weak resonant probe beam through the nanofiber that couples to the atoms via the evanescent field. We can observe the light-matter-coupling by either measuring the absorption or the phase shift experienced by the probe light. Furthermore, we demonstrate that the off resonant measurements are non-destructive with respect to the number of trapped atoms. Finally, we present first results on Autler-Townes state splitting and electromagnetically induced transparency. These results open the route towards the manipulation and storage of light with coherently prepared fiber-coupled atomic ensembles. Potential applications include fiber-coupled quantum memories and quatum repeaters as well as many-body physics with light-matter quasi-particles.

Financial support by the Volkswagen Foundation, the ESF and the FWF Doctoral Programme CoQuS is gratefully acknowledged.

A 23.2 Thu 14:45 SCH A118

AC-Stark shift and photoionization of Rydberg atoms in an optical dipole trap — •Tobias Weber[1], Frank Markert[1], Peter Würtz[1], Andreas Koglbauer[2], Tatjana Gericke[1], Andreas Vogler[1], and Herwig Ott[1] — [1]Fachbereich Physik, Universität Kaiserslautern — [2]Institut für Physik, Universität Mainz

We present the measurement of the AC-Stark shift of the $14D_{5/2}$ Rydberg state of rubidium 87 in an optical dipole trap formed by a focussed CO_2-laser. We find good quantitative agreement with the model of a free electron experiencing a ponderomotive potential in the light field. In order to reproduce the observed spectra we take into account the broadening of the Rydberg state due to photoionization and extract the corresponding cross-section.

A 23.3 Thu 15:00 SCH A118

EIT cooling of an atom in optical resonators — •Marc Bienert and Giovanna Morigi — Theoretische Quantenphysik, Universität des Saarlandes, 66041 Saarbrücken, Germany

We consider a single, harmonically trapped atom in an optical resonator. The internal level configuration of the atom is Λ-shaped. One of the dipole transitions is coupled to a strong laser field, whereas the other transition interacts with the quantised light field of the optical resonator. The resonator is additionally pumped by a weak probe laser. Similar configurations have been used recently to demonstrate electromagnetically induced transparency of a single atom [1]. We investigate the mechanical effects of the radiation acting on the atomic motional degree of freedom. The analysis is performed in the Lamb-Dicke limit. We investigate several cooling mechanisms occurring in this configuration, among them an analog to EIT cooling in free space and cavity sideband cooling. Further cooling schemes which rely on quantum interference can be identified. Finally, we compare our findings with experimental results which show alternating cooling and heating areas around two-photon resonance [2].

[1] M. Mücke et al., Nature **465**, 755 (2010)
[2] T. Kampschulte et al., Phys. Rev. Lett. **105**, 153603 (2010)

A 23.4 Thu 15:15 SCH A118

Trapping ions with lasers — •Cecilia Cormick and Giovanna Morigi — Theoretische Physik, Universität des Saarlandes, D-66041 Saarbrücken, Germany

This work theoretically addresses the physics underlying the trapping of an ionized atom with a single valence electron by means of lasers. In our model, the coupling between the ion and the electromagnetic field includes the charge monopole and the internal dipole, within a multipolar expansion of the interaction Hamiltonian. Specifically, we perform a Power-Zienau-Woolley transformation, taking into account the motion of the center of mass. The net charge produces a correction in the atomic dipole which is of order m_e/M with m_e the electron mass and M the total mass of the ion. With respect to neutral atoms, there is also an extra coupling to the laser field which can be approximated by that of the monopole located at the position of the center of mass. These additional effects, however, are shown to be very small compared to the dominant dipolar trapping term, and we can conclude that the effect of the net charge on dipolar trapping is negligible.

A 23.5 Thu 15:30 SCH A118

Quantum jumps triggered by atomic motion — Mauricio Torres[1], •Marc Bienert[1,2], Stefano Zippilli[3,4], and Giovanna Morigi[2,3] — [1]Instituto de Ciencias Físicas, Universidad Nacional Autónoma de México, Cuernavaca, Morelos, Mexico — [2]Theoretische Quantenphysik, Universität des Saarlandes, 66041 Saarbrücken, Germany — [3]Departament de Física, Universitat Autònoma de Barcelona, E 08193 Bellaterra, Spain — [4]Fachbereich Physik and research center OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

We theoretically study the occurrence of quantum jumps in the resonance fluorescence of a trapped atom. In our approach the atom is laser cooled in a configuration of levels such that the occurrence of a quantum jump is associated to a change of the vibrational center-of-mass motion by one phonon. The statistics of the occurrence of the dark fluorescence period is studied as a function of the physical parameters and the corresponding features in the spectrum of resonance fluorescence are identified. We discuss the information which can be extracted on the atomic motion from the observation of a quantum jump in the considered setup.

A 23.6 Thu 15:45 SCH A118

Neuartige Transportoperationen in planaren und dreidimensionalen Paulfallen mittels variabler Radiofrequenzamplituden — •Andreas Kehlberger[1], Stefan Ulm[1], Georg Jacob[1], Todd Karin[2], Isabela Le Bras[2], Nikos Daniilidis[2], Hartmut Häffner[2], Ferdinand Schmidt-Kaler[1] und Kilian Singer[1] — [1]Institut für Physik, Johannes Gutenberg Universität Mainz, Staudinger Weg 7, 55128 Mainz, Germany — [2]Department of Physics, University of California, 366 LeConte Hall #7300, Berkeley, CA 94720-7300, USA

Bisherige Paulfallen sind in der Lage mittels variabler DC Potentiale Ionen und Ionenketten entlang einer Fallenachse zu positionieren und Ionenkristalle zu trennen. Mittels variabler Radiofrequenzamplituden können wir diese Operationen nun auf alle drei Dimensionen ausdehnen. Wir präsentieren optimierte planare[1] und drei dimensionale Fallengeometrien um Ionen auf eine genau definierte Position zu platzieren. Desweiteren erläutern wir numerische Methoden um entsprechende Kalkulationen durchzuführen. Die Methoden berücksichtigen experimentelle Vorgaben und sind in der Lage anhand der Felder die benötigten Radiofrequenz Spannungen und Ionentrajektorien für gewünschte Transportoperationen zu optimieren.

Refrences

1. T. Karin, I. Le Bras , A. Kehlberger , K. Singer , N. Daniilidis, H. Häffner, arXiv:1011.6116 (2010)

A 24: Attosecond physics I

Time: Thursday 16:30–18:30 Location: BAR 205

A 24.1 Thu 16:30 BAR 205

Probing single-photon ionization on the attosecond time scale — •Kathrin Klünder[1], J. Marcus Dahlström[1], Mathieu Gisselbrecht[1], Thomas Fordell[1], Marko Swoboda[1], Diego Guénot[1], Per Johnsson[1], Jérémie Caillat[2], Johan Mauritsson[1], Alfred Maquet[2], Richard Taïeb[2], and Anne L'Huillier[1] — [1]Lund University, Department of Physics, Lund, Sweden — [2]Université Pierre et Marie Curie, Laboratoire de Chimie Physique-Matière et Rayonnement, France

Attosecond light sources allow us to measure fundamental quantities such as the time it takes for an electron to escape from an atom after photoabsorption [1]. We present an interferometric technique to time resolve photoemission on the attosecond time scale. We employ an attosecond pulse train for the excitation and a weak infrared laser field to probe the outgoing electron wave packet. We determine a difference in photoemission delay between electrons emitted from the 3s and from the 3p shells in argon as a function of excitation energy. We address the question of the influence of the probing field in the measurement process on this short time scales.

[1] M. Schultze *et al.*, Science **328**, 1658 (2010).

A 24.2 Thu 16:45 BAR 205

Qspider: Retrieval of the amplitude and phase of an electron wave packet using with attosecond and infrared pulses. — •Alexis Chacon[1] and Camilo Ruiz[2] — [1]Grupo de Investigación en Óptica Extrema (GIOE), Universidad de Salamanca, Pl. de la Merced s/n 37008 Salamanca. Spain — [2]Centro de Laseres Pulsados (CLPU), Pl. de la Merced s/n 37008 Salamanca. Spain

There is a large collection of optical techniques to characterize the amplitude and phase of a ultrashort laser pulse. Among these techniques there are SPIDER, FROG, FROG CRAB and RABBIT, etc. We propose to transfer some of the ideas of these optical techniques used for laser pulses but now for the characterization of electron wave packets (EWP) in atoms and molecules using attosecond pulse trains and infrared pulses. In particular, we try to implement the SPIDER technique to retrieve the amplitude and phase of an electron wave packet.

The SPIDER technique for laser pulses is based in the construction of an spectral interferogram and the application of an algebraic algorithm to obtain the spectral phase. The main elements used to build this interferogram are: 1) the generation of two copies of the pulse, 2) the use of a time delay between the two copies, 3) the introduction of a spectral shearing, and 4) the measurement of the spectral interferogram. The same steps can be implemented with EWP using the tools of attoscience.

In this paper we show the demonstration of the technique by retrieving the amplitude and phase of the electric dipole in the H_2^+ molecule and exploring the best parameters for an accurate retrieval.

A 24.3 Thu 17:00 BAR 205

Testing electron correlation in Helium using attosecond pulses — •Camilo Ruiz — Centro de Laseres Pulsados (CLPU), Plaza de la Merced s/n, Salamanca 37008, Spain

Using a full quantum model beyond the one dimensional model, we are able to study the double correlated double ionization of Helium in several regimes. For example in the near IR, we have investigated the correlated momentum distribution of both electrons from nonsequential double ionization of helium in a $\lambda = 800$ nm laser, with intensity $I = 4.5 \times 10^{14}$ W/cm^2.

We observe a fingerlike structure in the correlated electron momentum distribution that can be interpreted as a signature of the microscopic dynamics in the recollision process. To study related process such as the excitation by recollision we make use of attosecond pulses to probe the dynamics of ionization. In this paper we introduce this novel technique to estudy the interaction that could lead increase the accuracy of the description of the correlated processes.

A 24.4 Thu 17:15 BAR 205

Interference of two attosecond pulses in the process of ionization gating — •Christian Ott, Philipp Raith, Michael Schönwald, Andreas Kaldun, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

High-order harmonics are generated in neon using few-cycle ($\sim$ 6 fs) carrier-envelope-phase(CEP)-stabilized laser pulses from a commercial TiSa laser amplifier in the 10^{14} W/cm^2 intensity regime. Exploiting spatio-temporally designed phasematching conditions resulting in ionization gating on the leading edge of the driving laser pulse, interference patterns of few (predominantly two) attosecond pulses in the 70 to 100 eV XUV spectral range have been experimentally observed in our lab at MPIK. The CEP dependence of these interference patterns will be presented, analyzed and compared to the theoretically expected phasematching response of coherently driven macroscopic media in the ionization gating regime. The results demonstrate the possibility to use collective coherence properties of a nonlinear medium towards attosecond pulse shape control.

A 24.5 Thu 17:30 BAR 205

High Harmonic Generation from liquid water droplets — •H.G. Kurz[1,2], D.S. Steingrube[1,2], T. Vockerodt[1,2], E. Schultz[1,2], D. Ristau[3], M. Lein[4], U. Morgner[1,2,3], and M. Kovacev[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Deutschland — [2]QUEST - Centre for Quantum Engeneering and Space-Time Research — [3]Laser Zentrum Hannover e.V., Deutschland — [4]Institut für theoretische Physik, Leibniz Universität Hannover, Deutschland

The generation of coherent radiation within the extreme ultraviolet spectral region is a vastly-growing research area of modern quantum optics. High Harmonic Generation (HHG) is based on nonlinear frequency conversion in gases, liquids and bulk media. With increasing target density, an enhancement of the conversion efficiency can be observed. Not only atoms serve as a target, but also clusters and molecules are extensively studied.

In this contribution, a micrometer-sized liquid water droplet source for debris-free HHG is presented, combining a high density with a molecular target. The droplets are prepared under vacuum condition, preventing reabsorption effects. The harmonic radiation is generated with a 100 fs, 795 nm laser pulse, provided by a chirped pulse amplification laser system. Results of pump-probe experiments and parametric studies concerning phase-matching effects are shown.

A 24.6 Thu 17:45 BAR 205

Beiträge der Elektronentrajektorien zur Erzeugung hoher harmonischer Strahlung in einer Semi-Infiniten Gaszelle — •Martin Kretschmar, Daniel S. Steingrube, Emilia Schulz, Uwe Morgner und Milutin Kovacev — Leibniz Universität Hannover, Institut für Quantenoptik, Welfengarten 1, D-30167 Hannover, Germany

Die Entstehung hoher harmonischer Strahlung (HHG) im Bereich des Plateaus wird weitestgehend durch zwei verschiedene Elektronentrajektorien bestimmt, welche sich aufgrund ihrer unterschiedlichen Kohärenzzeiten unterscheiden lassen. Untersuchungen hierzu wurden bereits am Gasjet durchgeführt [1]. Wir untersuchen die Beiträge der Elektronenbahnen und deren Beeinflussung über Variation einzelner Phasenanpassungsparameter in einer Semi-Infiniten Gaszelle. Hierzu wird ein Verstärkersystem mit einer Zentralwellenlänge von 800 nm sowie einer Pulsdauer von 30 fs nach einem Mach-Zehnder-Interferometer in die Semi-Infinite Gaszelle fokussiert, in welcher hohe harmonische Strahlung an Xe erzeugt wird. Wir identifizieren die Beiträge der Trajektorien zur harmonischen Strahlung über deren unterschiedliche Kohärenzzeiten. Darüber hinaus ist es möglich die Trajektorienbeiträge zu kontrollieren und somit die Erzeugung von Attosekundenpulsen zu beeinflussen.

[1] Bellini et al. Phys Rev A, Vol 60, No 6 , 1999

A 24.7 Thu 18:00 BAR 205

Sideband oscillation by two-color ionization experiments — •Alexander Sperl, Helga Rietz, Ram Gopal, Andreas Fischer, Konstantin Simeonidis, and Joachim Ullrich — MPI für Kernphysik, 69115 Heidelberg

Noble gas atoms can be ionized by irradiation with an extreme-ultraviolet (XUV) attosecond pulse train emitting electron wave packets. These pulses are synthesized from harmonics generated by focusing an infrared laser beam (IR with a pulse duration of 30 fs, single pulse energy of 0.6 mJ and wavelength at 777 nm) into an argon gas tube at a pressure of 80 mbar. Both the attosecond pulse train and the electron wave packets can be characterized by superimposing the XUV and the fundamental IR fields and considering the energy transfer to the electron wave packets as a function of time delay between both fields resulting in oscillating energy-sidebands, a technique referred to as RABBIT (reconstruction of attosecond beating by interference of two-photon transitions) [1], [2]. The three-dimensional dynamics of the photoelectrons however can now be studied in more detail by combining the XUV light source with a Reaction Microscope. In this context we changed the polarisation of the XUV and the IR fields with respect to each other by 90°, detecting a remarkable change of the angular distribution of the sideband-photoelectrons.

[1] H. G. Muller, et. al., Appl. Phys. B 74, 2002 [2] P. Johnsson, et. al., Journal of Modern Optics 53, 2006

A 24.8 Thu 18:15 BAR 205

Attosecond dynamics in few-cycle laser driven electron emission from sharp metal tips — •Markus Schenk, Michael Krüger, and Peter Hommelhoff — Max-Planck-Insitut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching bei München, Germany

By focusing low-power few-cycle Ti:Sa pulses tightly onto sharp tungsten tips strong-field effects such as peak suppression and peak shifting in ATP spectra have been observed [1,2]. Here we use carrier-envelope phase (CEP) stabilized pulses and measure the electron energy spectra for varying CEP. We observe a CEP dependent modulation in the current that increases in amplitude to about 40% for higher-energetic electrons. Furthermore we observe a clear change in the spectral peak visibility when the phase is changed by π. These findings can be understood in the picture of time-energy interferometry of the electron emission. For a double slit, fringes result in the energy domain, whereas no fringes result for the single slit. We compare our experimental findings with numerical integration of the time-dependent Schrödinger equation and find good agreement. With this interpretation sub-optical cycle (attosecond) and electric-field sign sensitive emission dynamics results. This system is complementary in nature to atomic systems, which is why we expect it to answer open questions of attosecond physics.

[1] M. Schenk, M. Krüger, P. Hommelhoff, accepted for publication in Physical Review Letters (2010)

[2] see contribution of M. Krüger et al. at this conference

A 25: Ultra-cold plasmas and Rydberg systems I

Time: Thursday 16:30–18:30 Location: BAR 106

Invited Talk A 25.1 Thu 16:30 BAR 106

Conical intersections in an ultracold gas — •Sebastian Wüster, Alexander Eisfeld, and Jan-Michael Rost — MPIPKS Dresden

We find that energy surfaces of more than two atoms or molecules interacting via transition dipole-dipole potentials generically possess conical intersections (CIs). Typically only few atoms participate strongly in such an intersection. For the fundamental case, a circular trimer, we show how the CI affects adiabatic excitation transport via electronic decoherence or geometric phase interference. These phenomena may be experimentally accessible if the trimer is realized by light alkali atoms in a ring trap, whose interactions are induced by off-resonant dressing with Rydberg states. Such a setup promises a direct probe of the full many-body density dynamics near a CI.

A 25.2 Thu 17:00 BAR 106

Atom-molecule coherence and Ramsey interferometry in ultracold Rydberg gases — •Jonathan Balewski, Björn Butscher, Johannes Nipper, Robert Löw, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart

Ultralong-range Rydberg molecules are bound states of a Rydberg atom with ground state atoms [1]. We report on experiments studying the coherence properties of this new class of molecular bond. We demonstrate the coherent transfer of initially free pairs of rubidium ground-state atoms to ultralong-range Rydberg molecules using rotary echo and Ramsey-pulse sequences. The coherent evolution of the molecular system is characterized by measuring the timescales for the energy-conserving dephasing rate, T_2, and for non-energy-conserving decay processes, T_1 [2].

Furthermore, these Ramsey experiments can be viewed as an atom-molecule interferometer where the unbound ground state atoms and the ultalong-range Ryberg molecules form two branches. The relative phase in the arms of such an interferometer can be precisely controlled and varied over a wide range using additional electric field pulses. Besides this proof of principle, this technique provides a phase sensitive tool to measure interactions between Rydberg atoms or molecules.

[1] V. Bendkowsky et al., Nature **458**, 1005 (2009)

[2] B. Butscher et al., Nature Physics, nphys1828 (2010)

A 25.3 Thu 17:15 BAR 106

Many-body spin interactions and the ground state of a dense Rydberg lattice gas — •Igor Lesanovsky — University of Nottingham, School of Physics and Astronomy, University Park, Nottingham NG7 2RD, United Kingdom

We study a one-dimensional atomic lattice gas in which Rydberg states are excited by a laser and whose external dynamics is frozen. We identify a parameter regime in which the Hamiltonian is well-approximated by a spin Hamiltonian with quasi-local many-body interactions and possesses an exact analytic ground state solution. This is due to the fact that for certain parameters the Hamiltonian can be approximately written in a so-called stochastic matrix form. The ground state is then a superposition of all states of the system that are compatible with an interaction induced constraint weighted by a fugacity. We perform a detailed analysis of this state which exhibits a cross-over between a paramagnetic phase with short-ranged correlations and a crystal. Moreover, we discuss its entanglement properties and outline an experimental procedure for achieving a maximally entangled state.

[1] I. Lesanovsky, arXiv:1010.2349 (2010)

A 25.4 Thu 17:30 BAR 106

Creating strongly coupled plasmas via the dipole blockade in ultracold Rydberg gases — •Georg Bannasch and Thomas Pohl — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden

A major challenge in the field of ultracold plasmas is the creation of strongly coupled charges. Since such plasma is typically created by photoionization of spatially uncorrelated ultracold atoms, the subsequent plasma relaxation leads to tremendous heating and, thus, precludes the development of strong correlations.

Here we propose a double-pulse ionization scheme for plasma creation that exploits the dipole blockade between highly excited Rydberg atoms. It is shown that this "pump-probe" type sequence produces strongly correlated ions, which thereby limits subsequent disorder-induced heating. We thoroughly study the involved steps to discuss the feasibility of our approach and give achievable coupling under realistic conditions.

A 25.5 Thu 17:45 BAR 106

Quantum-Spin dynamics with ultracold Rydberg atoms — •Rejish Nath[1], Daniel Charrier[1], Igor Lesanovsky[2], Andreas Läuchli[1], and Thomas Pohl[1] — [1]MaxPlanck Institute for the Physics of Complex Systems, Nöthnitzer strasse 38, D-01187, Dresden, Germany — [2]University of Nottingham, University Park, Nottingham, United Kingdom.

Rydberg atoms are emerging as a promising system to realize spin Hamiltonians with current experimental capabilities. As pointed out previously, groundstate-coupling to one Rydberg state leads to an effective spin-1/2 Ising-type model. Here we discuss an implementation of spin-1 Hamiltonians by exciting two distinct nS Rydberg states. It is shown that this not only increases the spin dimension but results in qualitatively different behavior due to the emergence of a "van der Waals hopping" term. Focussing on experimentally relevant parameters, we will present the resulting phase diagram in several simplifying limits.

A 25.6 Thu 18:00 BAR 106

Excitation and entanglement transport in a flexible rydberg chain — •Sebastian Möbius, Sebastian Wüster, Cenap Ates, Alexander Eisfeld, and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden

In a regular, flexible chain of Rydberg atoms, a single electronic excitation localizes on two atoms that are in closer mutual proximity than all others. We show how the interplay between excitonic and atomic motion causes electronic excitation and diatomic proximity to propagate through the Rydberg chain as a combined pulse. In this manner entanglement is transferred adiabatically along the chain, reminiscent of momentum transfer in Newton's cradle[1].

[1] S. Wüster, C. Ates, A. Eisfeld and J.-M. Rost, Phys. Rev. Lett. **105**, 053004 (2010)

A 25.7 Thu 18:15 BAR 106

Relaxation dynamics of an ultracold Rydberg lattice gas — •Cenap Ates and Igor Lesanovsky — School of Physics and Astronomy, University of Nottingham, NG7 2RD Nottingham, United Kingdom

The discussion about if and how a closed non-equilibrium quantum system relaxes to an equilibrium state compatible with familiar statistical mechanics has gained renewed interest, since experiments are on the horizon that can implement the theoretically studied models with ultracold atomic systems. In this spirit, the long-time dynamics of a coherently driven Rydberg ring was recently studied theoretically. It was shown that for strong Rydberg-Rydberg interactions "classical" observables like the number of excited particles indeed relax towards a state which can be characterized by a thermal distribution [1].

Here we focus on the relaxation process itself. We show that the time it takes to reach the equilibrium state depends non-trivially on the interaction strength. In particular, we demonstrate that the equilibration process dramatically slows down a the point, where the Rydberg blockade sets in.

[1] I. Lesanovsky, B. Olmos and J.P. Garrahan, Phys. Rev. Lett. 105, 100603 (2010)

A 26: Poster III

Time: Thursday 16:00–18:30 Location: P2

A 26.1 Thu 16:00 P2

A two-dimensional MOT as a cold atomic source for ion-atom collision studies — •Dominik Globig[1], Renate Hubele[1], Aaron C. LaForge[1], Aditya Kelkar[1,2], Katharina Schneider[1,2], Martin Sell[1], Xincheng Wang[1,2], and Daniel Fischer[1] — [1]MPI für Kernphysik, Heidelberg, Germany — [2]EMMI at GSI, Darmstadt, Germany

A new atomic beam source was designed and developed at the MPIK which uses optical pumping combined with a spatially-dependent magnetic field to produce a cold atomic beam for use in ion-atom collision studies at the TSR at MPIK. A "push" laser is used to transfer the precooled atoms from this two-dimensional MOT to a three-dimensional one which is combined with a reaction microscope (MOT-REMI) capable of performing kinematically complete experiments with an energy resolution about ten times greater than that of a conventional reaction microscope. A 2D-MOT was chosen over other atomic target sources (e.g Zeeman slower) for its collimated beam which provides a higher density of atoms and for its compact design.

A 26.2 Thu 16:00 P2

Few-Body Dynamics studied with the In-Ring Reaction Microscope at the TSR of MPIK — •Katharina Schneider[1,2], Daniel Fischer[1], Michael Schulz[3], Marcelo Ciappina[4], Manfred Grieser[1], Siegbert Hagmann[5], Aditya Kelkar[1,2], Tom Kirchner[6], Kai-Uwe Kühnel[1], Aaron LaForge[1], Xincheng Wang[1,2], Robert Moshammer[1], and Joachim Ullrich[1] — [1]MPI für Kernphysik, Heidelberg, Germany — [2]EMMI at GSI, Darmstadt, Germany — [3]Missouri University of Science and Technology, Rolla, USA — [4]ICFO, Barcelona, Spain — [5]GSI, Darmstadt, Germany — [6]York University, Toronto, Canada

Ionization and charge transfer processes in ion-atom collisions are studied fully momentum resolved with a Reaction Microscope, which is implemented into the ion storage ring TSR at MPIK. The low emittance and high intensity of the ion beam allows to obtain even fully differential spectra of processes with small cross sections. By measurements of double ionization of helium, analysed by means of four-particle Dalitz plots, the significance of electron-electron correllation was studied over a broad range of perturbations. For studying Radiative Electron Capture (REC), a detector dedicated to measure low energy X-ray photons is implemented into the Reaction Microscope. REC is the dominant capture process in collisions of atoms and highly charged ions at high velocities. As it can be seen as the inverse process, REC data can provide information of atomic photo-ionization with high-energy photons in the strong-field domain. We aim at first kinematically complete measurements of REC, first results will be presented.

A 26.3 Thu 16:00 P2

Kinematically complete measurements for electron capture in collisions of keV energy ions with atomic and molecular targets. — •Aditya Kelkar, Xincheng Wang, Daniel Fischer, Robert Moshammer, and Joachim Ullrich — Max Planck Institut fuer Kernphysik, Heidelberg, Germany

We report on fully differential cross section measurements of electron capture to slow heavy ions using a Reaction Microscope. The Reaction Microscope is optimized for efficient detection of recoil-ions with large momentum and high energy (up to 200 eV) electrons. In order to achieve this we implemented large area position sensitive MCP detectors with central holes for the passage of the projectile beam. A ring electrode was also implemented within the recoil-ion drift tube for collection of recoil-ions produced with large transverse momentum on to the MCP. The experimental setup has been augmented with a low energy beam line optimized for transfer of few keV/q singly and doubly charged atomic/molecular ions obtained from a penning ion source or highly charged ions from an EBIT. The present experimental setup is adequate for collecting fully differential data sets for several reaction channels like single capture, double capture and resonant capture etc. Details of the experimental setup and results of ongoing measurements will be presented.

A 26.4 Thu 16:00 P2

Mutual Projectile and Target Ionization in $N^{4+,5+}$ +He collisions — •Xincheng Wang[1], Aditya Kelkar[1], Katharina Schneider[1], Michael Schulz[2], Bennaceur Najjari[1], Alexander Voitkiv[1], Manfred Grieser[1], Robert Moshammer[1], Daniel Fischer[1], and Joachim Ullrich[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, — [2]Physics Department and LAMOR, University of Missouri-Rolla,

We have studied mutual projectile and target ionization processes in 1MeV/amu N^{4+} and N^{5+} +He collisions in a kinematically complete experiment. The data has been analyzed with four-particle Dalitz plots, in which multiple differential cross sections are presented as a function of the momenta of all four particles. Theoretical results from various quantum-mechanical models are convoluted with classical elastic scattering (nucleus-nucleus interaction) and the comparisons to experimental results show qualitatively good agreement with eikonal calculations. Better agreement is achieved for N^{5+} +He collision, while some discrepancies are observed for N^{4+} +He collision, where the significance of high order effects is underestimated.

A 26.5 Thu 16:00 P2

Design, construction and operation of a small ion source for measurements in a linear Paul trap — •Sita Eberle, José R. Crespo López-Urrutia, and Maria Schwarz — Max-Planck-Institut für Kernphysik

Gas atoms can be ionized by electron impact ionization in electron beam ion traps (EBIT) and sources (EBIS). A small EBIS based on a pair of Helmholtz coils with a low magnetic field has been designed and built at the MPIK Heidelberg for test operations with a cryogenic linear Paul trap. The device has the advantage of occupying an area of only about one square meter and is more than able to produce the required singly ionized gas atoms. At typical electron beam currents of 0,5mA and energies of 1keV, an ion yield of ~50nA is obtained. Different gases have been tested and yields have been compared with the values predicted by rate estimates.

A 26.6 Thu 16:00 P2

Electron-Positron Pair Creation in Heavy Ion Collisions — •Manuel Mai — Physikalisches Institut, Universität Heidelberg

A theoretical description of highly charged ion collisions is given. At collision energies near the Coulomb barrier the formation of so quasi molecules can happen, with a ground state that dives into the "Dirac sea" at short distances of the ions. In that way an electron-positron pair can be created.

For two ions traveling on classical Rutherford trajectories the two center Dirac equation is solved numerically with B-Splines. The solutions form a quasi complete set of basis functions at each instant of time. By means of coupled-channel calculations we perform the time evolution of the system, i.e. the transition from one basis set to another. Results are obtained in the monopole approximation in which only a monopole contribution of the potential is used in the Dirac equation.

A 26.7 Thu 16:00 P2

Electron induced dissociation of H2 and CO2: molecular frame (e, 2e) spectroscopy — •Xueguang Ren, Thomas Pflüger, Shenyue Xu, Arne Senftleben, Alexander Dorn, and Joachim Ullrich — Max-Planck-Institut für Kernphysik , 69117 Heidelberg, Germany

Collisions of energetic electrons with molecules that induce chemical and physical reactions are of fundamental importance for a range of areas from plasma physics to radiation damage in living tissue. The study of dissociative ionization of molecules where the molecular ion is fragmenting can provide detailed insight into the molecular reaction dynamics. In this work experiments were performed for H2 and CO2 at low collision energy (E0 = 54.5 eV). A Reaction Microscope was used to measure the momentum vectors of all charged particles emerging from the collision. While for fast electron impact ionization can be well understood as a pure binary collision of the projectile and the target electron, at low energy the ionic potential and, therefore, the molecular structure and its alignment relative to the projectile beam can strongly influence the electron emission pattern. This was demonstrated recently in non-perturbative calculations [1]. Therefore, an important aspect of our measurement is the determination of the molecular axis alignment during the collision. This was realized by detecting the momentum vector of an ionic fragment resulting from the post-collision dissociation of the molecular ion. Fully differential cross sections as well as their interpretation will be delivered at the conference. [1] J. Colgan, et al., Phys. Rev. Lett. 101, 233201 (2008).

A 26.8 Thu 16:00 P2

A Concept for a Spin-Polarized Electron Target in a Heavy Ion Storage Ring — •Michael Lestinsky and Thomas Stöhlker — GSI Helmholtzzentrum für Schwerionenforschung, D-64291 Darmstadt

We are presently designing a spin-polarized electron target. It builds upon a photocathode electron gun which is well established to serve as an efficient source of highly polarized electron beams. A mix of electrostatic and magnetic fields shall permit an arbitrary orientation of the incident electron polarization. Further, the interaction zone of the electrons with ions circulating in the storage ring will be featuring a flexible setup such that it allows for either transverse or longitudinal beam alignments. Here we lay out the planned design and report on its present status.

First experiments are foreseen to address a complete description of polarized electron induced emission of X-rays in inelastic collisions with heavy ions. These requires the knowledge of the full quantum state of all involved reactants, in particular determining the orientation of the polarization vector. We will employ Compton polarimetry of X-ray photons, which has become in our laboratory an established technique in such experiments. In the literature so far corresponding experiments were mostly carried out with unpolarized electron sources.

A 26.9 Thu 16:00 P2

Dominant interaction Hamiltonians — •Martin Gerlach and Jan-Michael Rost — Max-Planck-Institute for the Physics of Complex Systems, Dresden, Germany

Generic Hamiltonian systems do not show an obvious perturbative part, which makes it difficult to understand (or even calculate) their dynamics. Finding suitable approximations to such systems is therefore of general interest in order to gain a deeper understanding of the underlying principles. In this approach we try to separate the dynamics in time according to dominant interaction Hamiltonians. Being the canonical example in atomic physics, we apply this scheme to the classical dynamics of the helium atom [1].

[1] G.Handke, M.Draeger, and H.Friedrich, 1993, Physica A 197, 113

A 26.10 Thu 16:00 P2

Coulomb explosion of diatomic molecular clusters — •Alexey Mikaberidze, Ulf Saalmann, and Jan Michael Rost — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

If a cluster is fully stripped of its electrons, the ions find themselves in a strongly repulsive potential energy landscape and rapidly undergo Coulomb explosion. The full ionization of a cluster can be achieved in a few femtoseconds by applying an intense near infrared or x-ray laser pulse.

We find using classical molecular dynamics calculations that clusters of diatomic molecules explode in a manner significantly different from atomic clusters. Moreover, it makes a difference whether the molecules in the cluster are oriented randomly or aligned. These differences manifest in the final kinetic energy distributions of ions, which can be measured experimentally. Understanding the underlying mechanisms is interesting in the context of Coulomb explosion imaging and laser-induced ion acceleration.

A 26.11 Thu 16:00 P2

Angular anisotropy parameters in photoionization processes of spherical metallic cluster anions — •Myroslav Zapukhlyak and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden, Germany

Size-selected sodium cluster anions of approximately spherical form were studied by angle resolved photoelectron spectroscopy over a broad range of photon energies [1,2]. The role of possible correlation effects in this experiment has been discussed theoretically [3]. Recently, the measurements have been extended to copper and silver cluster anions [4]. When the anisotropy parameter dependence is plotted against the impulse of the photoelectron multiplied by the cluster radius, the obtained evolution of the beta parameter is very similar for the photoelectrons from l=4 levels for different cluster species. This striking similarity in the anisotropy parameter may be seen as a counter-argument of the distinct role of correlation effects in such photoionization processes at least for the weakest bound electrons. In this theoretical study we investigate the beta parameters with the goal to elucidate the underlying physics of the photoionization process, and compare our results with the available experimental data and theoretical calculations.

[1] C. Bartels, PhD thesis, University of Freiburg, Freiburg, (2008)
[2] C. Bartels et al., Science, 323, 1323 (2009)
[3] A. V. Solov'yov et al., Phys. Rev. A, 81, 021202 (2010)
[4] A. Piechaczek et al., In DPG Frühjahrstagung AMOP, (2010)

A 26.12 Thu 16:00 P2

Die Chemische Verschiebung der 2p-Rumpfniveaus freier Cluster — •Marlene Vogel[1], Felix Ameseder[2], Christof Ebrecht[2], Konstantin Hirsch[2], Christian Kasigkeit[2], Andreas Langenberg[1], Markus Niemeyer[2], Jochen Rittmann[1], Vicente Zamudio-Bayer[1], Bernd von Issendorff[3], Thomas Möller[2] und Tobias Lau[1] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie, Institut für Methoden und Instrumentierung der Synchrotronstrahlung, Albert-Einstein-Straße 15, D-12489 Berlin — [2]Technische Universität Berlin, Institut für Optik und Atomare Physik, EW 3-1, Hardenbergstraße 36, D-10623 Berlin — [3]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg

Für Silicium und Aluminium wurden die 2p-Rumpfniveau-Bindungsenergien freier, größenselektierter Clusterkationen X_n^+ mittels geeigneter Kanäle in Ionenausbeute-Spektroskopie mit durchstimmbarer weicher Röntgenstrahlung bestimmt. Die Analyse der relativen Verschiebungen der so gemessenen 2p-Bindungsenergien gewährt Informationen über das Vorkommen von unterschiedlichen chemischen Umgebungen der Atome im Cluster. Mit Hilfe von DFT-Rechnungen lassen sich diese experimentellen Befunde mit elektronischen Eigenschaften der für die Cluster vorhergesagten geometrischen Strukturen vergleichen.

A 26.13 Thu 16:00 P2

Electronic Structure of Transition Metal Doped Gold Clusters — •Konstantin Hirsch[1,2], Jochen Rittmann[2], Vicente Zamudio-Bayer[2], Marlene Vogel[2], Jörg Wittich[1], Silvia Forin[1], Christian Kasigkeit[1], Felix Ameseder[1], Jürgen Probst[2], Thomas Möller[1], Bernd von Issendorff[3], and Tobias Lau[2] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, EW 3-1, Hardenbergstraße 36, D-10623 Berlin — [2]Helmholtz-Zentrum Berlin für Materialien und Energie, Wilhelm-Conrad-Röntgen Campus / BESSY II, Institut für Methoden und Instrumentierung der Synchrotronstrahlung, Albert-Einstein-Str. 15, D-12489 Berlin — [3]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg

Small gold clusters show very suprising properties, like highly enhanced catalytical activity. The electronic properties of small clusters can be modified by doping with transition metal atoms. We investigated the local electronic structure of small doped gold clusters (Au_nM n=1-8, M=Sc,Ti,V,Cr) by means of X-ray absorption spectroscopy. The electronic structure is very sensitive to the doping and geometric structure of the cluster. Electron localization of the 3d orbitals of the impurity atom and shell closure effects in the gold host matrix can be deduced from comparison to atomic Hartree Fock calculations.

A 26.14 Thu 16:00 P2

Setup and first experiments with a new attosecond strong-field reaction microscope — •Martin Laux, Christian Ott, Philipp Raith, Andreas Kaldun, Claus-Dieter Schröter, Robert Moshammer, Joachim Ullrich, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

We present the experimental setup of a new reaction microscope to study interactions of ultrashort light pulses with atoms or molecules which is currently being constructed in our attosecond laboratory. The instrument allows to measure, in coincidence, the momenta of ions and electrons produced within the interaction. The reaction microscope is designed to detect electrons up to a kinetic energy of at least 100 eV to be matched to similar photon energies exhibited by our soft-x-ray attosecond pulses. The target can be any atomic or molecular gaseous system of interest but the first experiments will concentrate on strong-field interactions with rare gases to judge the performance of the instrument. The setup of the reaction microscope, including important design considerations, and the first experimental results along with some simulations will be shown. Finally, we will provide an outlook on future experiments now possible with the new device.

A 26.15 Thu 16:00 P2

Impact of hollow-atom formation on coherent x-ray scattering at high intensity — •Sang-Kil Son[1], Linda Young[2], and Robin Santra[1,3] — [1]Center for Free-Electron Laser Science, DESY, Germany — [2]Argonne National Laboratory, USA — [3]Department of Physics, University of Hamburg, Germany

X-ray free-electron lasers (FELs) are promising tools for structural determination of macromolecules via coherent x-ray scattering. The key obstacle for scattering imaging is radiation damage by ultraintense x-ray pulses. We develop a toolkit to treat detailed ionization, relaxation, and scattering dynamics for an atom within a consistent theoretical framework, and investigate the coherent x-ray scattering problem for a carbon atom including radiation damage. We find that the x-ray scattering intensity saturates at a high fluence but can be maximized by using a pulse duration much shorter than the relaxation time scales of the inner-shell vacancy states created. Under these conditions, both inner-shell electrons are removed, and the resulting hollow atom gives rise to a scattering pattern with little loss of quality for a desirable resolution. Our numerical results predict that in order to scatter from a carbon atom 0.1 photons per x-ray pulse, within a spatial resolution of 1.7 Å, a fluence of 10^7 photons/$Å^2$ per pulse is required at a pulse length of 1 fs and a photon energy of 12 keV. By using a pulse length of a few hundred attoseconds, one can suppress even secondary ionization processes in extended systems. The present results suggest that high-brightness attosecond x-ray FELs would be ideal for single-shot imaging of individual macromolecules.

A 26.16 Thu 16:00 P2

Photoionization and resonant photon scattering of highly charged iron ions — •C. Beilmann[1], J.R. Crespo López-Urrutia[1], M.C. Simon[1], S.W. Epp[1,2], R. Steinbrügge[1], J. Rudolph[1,3], S.N. Eberle[1], M. Leutenegger[4], A. Graf[5], T.M. Baumann[1], F.R. Brunner[1], P. Beiersdorfer[5], R. Follath[6], G. Reichardt[6], and J. Ullrich[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Max Planck Advanced Study Group at CFEL, Hamburg, Germany — [3]Justus-Liebig-Universität Gießen, Germany — [4]NASA Goddard Space Flight Center, Greenbelt MD, USA — [5]Lawrence Livermore National Laboratory, Livermore CA, USA — [6]Helmholtz-Zentrum Berlin - BESSY II, Berlin, Germany

Interactions of highly charged ions (HCI) and x-ray photons are important processes in astrophysical matter and for testing atomic structure theory. Resonant absorption of x-rays by HCI leads to excited states that can decay by autionization or radiative deexcitation. For the investigation of x-ray absorption, the trasportable electron beam ion trap FLASH-EBIT can be coupled to x-ray sources. Radiative deexcitation (RD) [1] as well as photoionization (PI) [2] were studied in separate experiments. We present results of an experiment at the synchrotron BESSY II, in which both decay channels could be detected simultaneously in the the astrophysically relevant ions Fe^{14+} and Fe^{15+}. The simultaneous detection at 800 eV of both RD and PI allows for the first time a detailed view of all branches of this process in HCI.

[1] S.W. Epp et al., Phys. Rev. Lett. 98, 183001 (2007)
[2] M.C. Simon et al., Phys. Rev. Lett. 105, 183001 (2010)

A 26.17 Thu 16:00 P2

Electron angular correlations in the sequential two-photon double ionization of noble gases — E.V. Gryzlova[1], A.N. Grum-Grzhimailo[1], •S. Fritzsche[2,3], and N.M. Kabachnik[1,4] — [1]Institute of Nuclear Physics, Moscow State University, Russia — [2]Department of Physics, University of Oulu, Finland — [3]GSI Helmholtzzentrum für Schwerionenforschung, Germany — [4]I. Institut für Theoretische Physik, Universität Hamburg, Germany

The study of non-linear atomic processes in the XUV and x-ray regime has attracted much interest following the recent developments of intense FEL sources. Among these processes, the two-photon double ionization (TPDI) of noble gases enables one to better understand the transition from a 'sequential' towards the 'simultaneous' emission of electrons [1,2]. For the TPDI emission of atoms, general expression for the angular correlation function has been derived and analyzed for suitable geometries in the experimental set-up of possible angle-differential measurements. Numerical calculations have been performed especially for the sequential TPDI of krypton [3] and xenon and will be presented in this contribution.

[1] S. Fritzsche *et al.*, J. Phys. B **41** (2008) 165601; B **42** (2009) 145602.
[2] M. Kurka *et al.*, J. Phys. B **42** (2009) 141002(FT).
[3] E. V. Gryzlova *et al.*, J. Phys. B **43** (2010) 225602.

A 26.18 Thu 16:00 P2

Nuclear coherent population transfer with x-ray laser pulses — •Wen-Te Liao, Adriana Pálffy, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

With present and upcoming light sources, the direct interaction between nuclei and super-intense laser fields has become feasible, opening the new field of nuclear quantum optics [1]. Inspired by atomic quantum optics techniques, we investigate the possibility of coherent nuclear population transfer between two ground states in a Λ-level scheme using two overlapping coherent x-ray light beams in a stimulated Raman adiabatic passage (STIRAP) setup [2]. The main question is under which conditions and parameters is control of nuclear states possible. We show that a truly coherent XFEL such as the future XFEL-Oscillator (XFEL-O) or seeded XFEL [3] to provide both probe and Stokes laser fields, together with acceleration of the target nuclei to achieve the resonance condition [1], allow for significant coherent nuclear population transfer at intensities within the present designed values. The most promising case requires laser intensities of 10^{17}-10^{19} W/cm^2 for complete nuclear population transfer. As relevant application, the controlled pumping or release of energy stored in long-lived nuclear states is discussed.

[1] T. J. Bürvenich, J. Evers and C. H. Keitel, Phys. Rev. Lett. **96** 142501 (2006).
[2] W.-T. Liao, A. Pálffy, C. H. Keitel, arXiv:1011.4423.
[3] E. L. Saldin *et al.*, Nucl. Instrum. Meth. A **475**, 357 (2001); K.-J. Kim *et al.*, Phys. Rev. Lett. **100** 244802 (2008).

A 26.19 Thu 16:00 P2

Differential cross sections for non-sequential double ionization of He by 52 eV photons from FLASH — •Moritz Kurka[1,2], Artem Rudenko[2,1], Yuhai Jiang[1], Lutz Foucar[2,1], Oliver Herrwerth[3], Matthias Kling[3], Claus Dieter Schröter[1], Robert Moshammer[1], and Joachim Ullrich[1,2] — [1]Max-Planck Institut für Kernphysik, 69117 Heidelberg — [2]Max-Planck Advanced Study Group at CFEL, 22607 Hamburg — [3]Max-Planck Institut für Quantenoptik, 85748 Garching

We present the results of recent measurements at the free-electron laser Hamburg (FLASH) on two-photon double ionization of helium at a photon energy of 52 eV. Inspecting the momentum distribution of He^{2+} ions we find first experimental evidence for an effect termed 'virtual sequential ionization' recently predicted in theoretical calculations [1]. Comparing our experimental data with state-of-the-art calculations solving the time-dependent Schrödinger equation we find good overall agreement except for cuts along the polarization direction, where we exhibit a siginifcant shift towards larger momenta [2]. [1] D.A. Horner et *al.*, PRA **76**, 030701 (2007). [2] M.Kurka et *al.*, NJP **12**, 073035(2010).

A 26.20 Thu 16:00 P2

Velocity Map Imaging of angular distributions of atomic photoelectrons produced in the XUV regime — •Torsten Hartmann[1], Tobias Vockerodt[1,2], Daniel Steingrube[1,2], Emilia Schulz[1,2], Uwe Morgner[1,2], and Milutin Kovačev[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]QUEST, Centre for Quantum Engineering and Space-Time Research

Angular distribution of atomic photoelectrons (PAD) is well understood concerning single-photon ionization and above threshold ionization. However, for the ionisation of an atom using two or three photon processes, theory predicts differing PADs. [1]

We present an experimental setup for the investigation of PADs which are dominated by the initial state of the atom and by rescattering effects with the parent ions only. This is done by using a high pulse energy laser source centered at a wavelength of 265 nm. With the help of a velocity map imaging spectrometer we expect to detect highly structured PADs from few-photon ionized Helium atoms and therefore validate the theoretical predictions.

[1] S. Bauch, M. Bonitz, "Angular distributions of atomic photoelectrons produced in the uv and xuv regime", PRA 78, 043403, 2008

A 26.21 Thu 16:00 P2

Fluorescence of a nanoplasma in clusters — Maria Müller[1], Marcus Adolph[1], •Daniela Rupp[1], Tais Gorkhover[1], Maria Krikunova[1], Yevheniy Ovcharenko[1], Lasse Schrödter[2], Tim Laarmann[2], and Thomas Möller[1] — [1]TU-Berlin, Institut für Optik und atomare Physik, Deutschland — [2]HASYLAB/DESY, Hamburg, Deutschland

The intense short wavelength radiation provided by free-electron-lasers (FEL) opened up many new fields of research in the last five years. FEL in Hamburg (FLASH) produces soft X-ray pulses with pulse durations of several ten femtoseconds and peak intensities up 10** photons/cm* achieved when focused on a small spot. One domain of interest is the interaction of these intensive XUV femtosecond light pulses with matter, in particular nanosized clusters which form the link between the atomic- and molecule physics on the one hand and solid state physics on the other.

Our investigation concentrates on the development of the electronic and optical properties as well as on the dissociation dynamics of clusters, irradiated by the XUV pulse.

In this poster we intend to present studies of fluorescence of pure and core-shell clusters with dependence on size. In comparison to synchrotron radiation the intensity by the FLASH is much higher and for this reason allows different excitation processes which lead to a nanoplasma in the core of clusters. Fluorescence spectroscopy is a promising approach to study the recombination processes that are taking place in the created nanoplasma.

A 26.22 Thu 16:00 P2

End Station for Low Density Matter Experiments at the FERMI XUV Free Electron Laser — •Raphael Katzy, Viktor Lyamayev, Marcel Mudrich, and Frank Stienkemeier — Universität Freiburg, Physikalisches Institut, D-79104 Freiburg, Germany

With the High-Gain Harmonic Generation technique the FERMI Free Electron Laser offers short pulses of extremely high brilliance and tuneable wavelengths in the range of 20-100 nm. In combination with precision timing this provides outstanding conditions for IR/VIS-XUV pump probe experiments.

The described end station is set-up to combine FERMI with molecular beam experiments. Several sources for a wide range of atomic, molecular and cluster beams are provided. Laser ablation techniques and oven cells can be used for beam doping. A Combination of VMI, TOF and X-ray imaging detectors allow simultaneous detection of electrons and ions as well as recording of laser beam diffraction patterns. The pulsed cryogenic and versatile cluster sources are presented.

A 26.23 Thu 16:00 P2

Entwicklung eines hocheffizienten Elektron-Ion-Koinzidenz-Flugzeitspektrometers für zeitaufgelöste Experimente im XUV — •Sascha Deinert, Leif Glaser, Markus Ilchen, Frank Scholz, Jörn Seltmann, Peter Walter und Jens Viefhaus — Deutsches Elektronen-Synchrotron, Notkestraße 85, 22607 Hamburg

Mit der Entwicklung hochbrillanter Röntgenstrahlungsquellen wie FLASH, PETRA III oder European XFEL wachsen nicht nur das Verständnis für Strukturen und Prozesse auf kleinster Ebene, sondern auch die Anforderungen an neue Diagnosegeräte. Ein nicht zu vernachlässigender Faktor ist dabei oft eine begrenzte Messzeit, die effiziente Experimente erfordert.

Vor diesem Hintergrund wird für die Untersuchung von Photoionisationsprozessen ein Elektron-Ion-Koinzidenz-Flugzeitspektrometer entwickelt, das an die Bedürfnisse von Weichröntgen-/XUV-Quellen im Allgemeinen und der P04 Variable Polarization XUV Beamline bei PETRA III (DESY, Hamburg) im Speziellen angepasst ist. Konzeptionell wird dabei ein kurzes Ionen-Flugzeitspektrometer in den Permanentmagneten eines sogenannten *magnetic-bottle*-Spektrometers für den Elektronennachweis implementiert. Die Kombination dieser beiden für sich effizienten Nachweismethoden sollte ebenfalls effiziente Koinzidenzmessungen gestatten. Modellsimulationen tragen zur Bestimmung der optimalen Parameter bei.

Vorgestellt werden Entwicklungsstand, Simulationsergebnisse und ein 25 mm kurzes Ionen-Flugzeitspektrometer nebst damit vorgenommene Messungen an Inertgasen bei FLASH und DORIS III (DESY).

A 26.24 Thu 16:00 P2

Relativistic signatures in the Kapitza-Dirac effect — •Sven Ahrens, Heiko Bauke, Carsten Müller, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The prediction of the Kapitza-Dirac effect [1], which is the diffraction of electrons by a standing wave of light, has been confirmed experimentally in recent years [2, 3]. The laser intensities, which were used in these experiments, are far below the highest intensities attainable with modern laser facilities and laser pulses with shorter wavelength are available today. Therefore, the question arises, if relativistic signatures of the Kapitza-Dirac effect are measurable in such strong laser fields.

We determine the time-evolution of the electron wavefunction by solving the Dirac equation analytically by a plane wave ansatz and with numerical simulations. We investigate the relativistic quantum dynamics and compare it to the non-relativistic Schrödinger theory focusing on relativistic signatures and spin effects in intense laser fields of short wavelengths.

[1] P. L. Kapitza, P. A. M. Dirac, Proc. Cambridge Philos. Soc. **29**, 297–300 (1933)
[2] D. L. Freimund, K. Aflatooni, H. Batelaan, Nature **413**, 142–143 (2001)
[3] P. H. Bucksbaum, D. W. Schumacher, M. Bashkansky, Phys. Rev. Lett. **61**, 1182–1185 (1988)

A 26.25 Thu 16:00 P2

Muon pair production in laser-assisted electron-positron collisions — •Sarah J. Müller and Carsten Müller — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

The production of muon-antimuon pairs in electron-positron collisions within an external laser field is studied. The effect of the laser field on the total cross section is examined in different kinematic regimes, in particular in the case where the free e^+e^- energies do not exceed the muon pair creation threshold of $2m_\mu c^2$. A comparison with the laser-free reaction is given regarding total cross sections and energy spectra.

A 26.26 Thu 16:00 P2

Multi-Photon Production and Single-Photon Annihilation of Electron-Positron Pairs — •Huayu Hu, Sven Augustin,

Carsten Mueller, and Christoph H. Keitel — Max Planck Institute for Nuclear Physics, Heidelberg

Electron-positron pairs can be produced via a multiphoton trident process in the collision of a relativistic electron beam with an intense laser field available nowadays [1]. We have performed a complete laser-dressed QED calculation of this process, and investigate the transition from the perturbative regime to the quasi-static regime [2]. An all-optical setup is proposed for future experiments on laser-induced pair production.

We have also studied a time-reversed process, namely electron-positron annihilation with single-photon emission where the extra momentum is absorbed by a nearby spectator electron. We discuss the significance of this process in dense plasma environments.

[1] D. Burke et al., Phys. Rev. Lett. 79, 1626 (1997).
[2] H. Hu, C. Müller, and C.H. Keitel, Phys. Rev. Lett. 105, 080401 (2010).

A 26.27 Thu 16:00 P2

Solving the time-dependent Dirac equation on massively parallel architectures — •Heiko Bauke and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

New parallel computing architectures emerged in the last few years, as for example, multicore systems and graphics processing units with general purpose computing capabilities, and it is expected that all major future computing architectures will be parallel. The new emerging ubiquitous parallel architectures challenge the computational physics community by calling for new parallel numerical algorithms. In our contribution, we present a massively parallel implementation of the Fourier split operator method for propagating time-dependent Dirac equation on multicore systems or graphics processing units. Our implementation is up to more than one order of magnitude faster than traditional sequential implementations. Thus, it allows to propagate wave functions over larger time intervals than it is possible with sequential programs and it permits to propagate broad wave functions with high accuracy. We will also present some applications of our code to problems of light matter interaction in intense laser fields.

A 26.28 Thu 16:00 P2

Unconventional rescattering in strong long-wavelength pulses — •Alexander Kästner, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzerstr. 38, D-01187 Dresden, Germany

In recent experiments a low-energy structure (LES) in the photoelectron spectra of atoms and small molecules in strong long-wavelength pulses was observed [1,2]. This effect cannot be reproduced by the strong-field approximation as well as the simple-man theory, which should apply particularly well for long-wavelengths. Classical trajectory calculations can clearly reproduce the experimental data. By means of a phase-space analysis we could identify a class of trajectories which cause the observed LES. For this class electrons are rescattered aside of the ion they were emitted from. In contrast to conventional backscattering the electron can be accelerated or decelerated. This effect is in competition with the drift velocity. The LES emerges when both effects cancel each other over a wide range of tunneling times.

[1] C.I. Blaga et al., Nature Phys. **5**, 335 (2009)
[2] W. Quan et al., Phys. Rev. Lett. **103**, 093001 (2009)

A 26.29 Thu 16:00 P2

Strong-field ionization dynamics of rare-gas-doped helium nanodroplets — •Marcel Mudrich[1], Siva Krishnan[2], Lutz Fechner[1], Frank Stienkemeier[1], Robert Moshammer[2], and Joachim Ullrich[2] — [1]Physikalisches Institut, Universität Freiburg — [2]Max-Planck-Institut für Kernphysik, Heidelberg

The strong-field ionization dynamics of rare-gas-doped helium nanodroplets is studied using few-cycle femtosecond laser pulses. In accordance with recent theoretical predictions [1], efficient double-ionization of the helium atoms in the droplets is observed when doping the droplets with only a few heavy rare-gas atoms. Pump-probe measurements with identical few-cycle pulses reveal the resonantly enhanced formation of singly and doubly ionized helium atoms at delay times in the range 200-600fs. Both pump-probe transients as well as ion spectra are most sensitive to variations of the droplet size.

[1] A. Mikaberidze, U. Saalmann, and J. M. Rost, Phys. Rev. Lett. 102, 128102 (2009)

A 26.30 Thu 16:00 P2

Phenomenological model of multiphoto-production of charged pion pairs on the proton — •Anis Dadi and Carsten Müller — MPI für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The production of charged pion pairs via multiphoton absorption from an intense X-ray laser wave colliding with an ultrarelativistic proton beam is studied. Our calculations include the contributions from both the electromagnetic and hadronic interactions where the latter are described approximately by a phenomenological potential. Order-of-magnitude estimates for $\pi^+\pi^-$ production on the proton by two- and three-photon absorption from the high-frequency laser field are obtained and compared with the corresponding rates for $\mu^+\mu^-$ pair creation.

A 26.31 Thu 16:00 P2

Interference in above-threshold ionization electron distributions from molecules — •Jost Henkel[1,2], Manfred Lein[2], and Volker Engel[1] — [1]Institut für Physikalische und Theoretische Chemie and Röntgen Research Center for Complex Material Systems, Am Hubland, 97074 Würzburg, Germany — [2]Institut für Theoretische Physik and Centre for Quantum Engineering and Space-Time Research (QUEST), Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany

We present quantum-mechanical studies on above-threshold ionization of H_2^+ and molecules with three atoms (H_3^{2+}) in two dimensions, varying their orientation relative to the laser polarization. Signatures of interfering emissions from the molecular centers are found in the angular resolved photoelectron momentum distribution. These structures are reproduced by an eikonal model and they deviate from a simple double-slit model, which ignores the electron-ion interaction. No clear signatures of interference are found in the electron energy spectrum.

A 26.32 Thu 16:00 P2

Characterization of the Carrier Envelope Phase (CEP) of a laser pulse by a non dispersive method — •Nicolas Camus, Manuel Kremer, Christian Hofrichter, Bettina Fischer, Vandana Sharma, Robert Moshammer, and Joachim Ullrich — Max Planck Institut for Nuclear Physics, 69117 Heidelberg, Germany

In few-cycle laser science, the CEP of the pulse (offset between the maximum of the electric field and the maximum of the envelope of the pulse) gives direct information on the shape of the electric field and consequently on the possible light-matter interactions induced by it. To measure it, interferometric techniques, such as the f-to-2f technique, are commonly used and provide stabilization of this phase. We report on a more recent technique based on Above Threshold Ionization (ATI) of rare gas atoms by linearly polarized laser pulses. The analysis of the left-right asymmetry of the escaping electrons allows a direct measurement of this phase. We present single-shot measurements done with a stereo-ATI device and compare them to phase stabilization with a dispersive method.

A 26.33 Thu 16:00 P2

Comparison of mixed quantum-classical and full quantum results for the multiphoton dissociation of H_2^+ — •Michael Fischer[1], Frank Grossmann[1], Rüdiger Schmidt[1], Jan Handt[2], Sebastian Krause[2], and Jan-Michael Rost[2] — [1]Institut fuer Theoretische Physik, Technische Universitaet Dresden,D-01062 Dresden, Germany — [2]Max Planck Institute for the Physics of Complex Systems, Noethnitzer Strasse 38, D-01187 Dresden, Germany

We present a mixed quantum-classical approach for the time-dependent dynamics of para-H_2^+ exposed to short intense laser pulses with 800 nm wavelength including all nuclear as well as electronic degrees of freedom. Depending on the initial vibrational state, the angular distributions of photo fragments show characteristic shapes in very good agreement with our full quantum calculations. The results are interpreted in the framework of two-dimensional adiabatic Floquet surfaces which depend on the internuclear separation and the rotation angle, demonstrating that adiabatic light-dressed surfaces are a useful concept also for full dimensional nuclear dynamics. With the help of kinetic energy release spectra, we are able to extract the contribution of different photon channels also in the quantum-classical case.

A 26.34 Thu 16:00 P2

Accurate Realization of Mach-Zehnder Interferometer via Dressed State Interference in Atomic Beam Spectroscopy. — •Vents Valle[1,2], Vyascheslavs Kascheyevs[2,3], Juris Ulmanis[2],

Zanda Krumina[2], and Aigars Ekers[2] — [1]Institute of Physics, Rostock University, Rostock D-18051, Germany — [2]Laser Center, University of Latvia, LV-1002 Riga, Latvia — [3]Faculty of Computing, University of Latvia, Riga LV-1586, Latvia

It is possible to manipulate energy levels of laser dressed atomic states via intensity and frequency of laser radiation. Such manipulations in abstract two level system may introduce additional time evolution that consists of two level crossings when the dressed energy levels are close (described approximately by Landau-Zener transitions) thus creating two alternative, in general, conjoined evolution paths between the crossings.

In our research we describe situation where an energy level of constant value is crossed twice by another energy level that evolves as a Gaussian curve. We develop a full model of such two level system using Mach-Zehnder interferometer as a base model and discuss accuracy of the model for different scenarios of energy levels' evolution.

A 26.35 Thu 16:00 P2

High Harmonic Generation for Pedestrians — •Carlos Zagoya[1], Christoph-Marian Goletz[2], Frank Grossmann[2], and Jan-Michael Rost[1] — [1]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Str. 38, D-01187 Dresden, Germany — [2]Institut für Theoretische Physik, Technische Universität Dresden, D-01062 Dresden, Germany

Using the idea of the strong field approximation together with the semiclassical Herman-Kluk propagator [1], we are able to observe the main features of high harmonic generation (HHG) in a one-dimensional one-electron atom under the influence of a strong laser field by using a simplified classical dynamics. It is shown that only few percent of the trajectories needed in full semiclassical calculations are sufficient in the strong field approach due to the fact that chaotic dynamics induced by the laser field is *not* present.

This work is in part supported by the DFG through grant GR 1210/4-2

[1] M. F. Herman and E. Kluk, Chem. Phys. **91**, 27 (1984)

A 26.36 Thu 16:00 P2

Simulation von Atomen, Molekülen und Clustern in starken Laserfeldern mittels zeitabhängiger Dichtefunktionaltheorie — •Volker Mosert und Dieter Bauer — Institut für Physik, Universität Rostock, 18051 Rostock, Germany

Eine Vielzahl interessanter physikalischer Phänomene, die bei Atomen, Molekülen und Clustern in starken Laserfeldern beobachtet werden, können nur mithilfe einer vollständig quantenmechanischen Beschreibung theoretisch nachvollzogen werden. Die Methode der zeitabhängigen Dichtefunktionaltheorie ermöglicht dies in Form von Computersimulationen.

Bei der Umsetzung dieser Methode liegt die größte Herausforderung aus numerischer Sicht in der effektiven Propagation der Kohn-Sham Orbitale. Die Zeitabhängigkeit des Hamiltonians durch das Feld des Lasers und das Austausch-Korrelationspotentials machen eine Näherung des quantenmechanischen Propagators notwendig, deren Eignung vom betrachteten System abhängt. Durch unsere Zielsetzung auch komplexe Systeme behandeln zu können, wird dabei die Nutzung von räumlichen Symmetrien, z.B. durch geschicktes wählen einer Basis, ausgeschlossen. Greift man in folge dessen auf ein kartesisches Gitter zurück, ist eine Zahl von 10^8 nötigen Gitterpunkten pro Orbital nicht untypisch.

Im Poster werden unsere Wahl der numerischen Verfahren erläutert und erste damit erzielte Resultate präsentiert.

A 26.37 Thu 16:00 P2

Precision investigation of the momentum distribution after strong-field ionization — •Ingo Dreissigacker and Manfred Lein — Institut für Theoretische Physik and Centre for Quantum-Engineering and Space-Time Research (QUEST), Leibniz Universität Hannover, Appelstr. 2, 30167 Hannover

Motivated by recent experimental progress in precision investigation of strong-field ionization by angular streaking [1] and velocity-map imaging [2], we employ linearly polarized half-cycle laser pulses to investigate the ionization process theoretically. Momentum distributions are calculated by numerical solution of the time-dependent Schrödinger equation for the hydrogen atom. For moderate intensities, the results support the picture that ionization occurs most probably at the peak of the field, without tunnelling delay time. The lateral width of the momentum distribution is in good agreement with tunnelling theory. Furthermore we find that the lateral width is maximum for electrons born near the peak of the field, even at high intensities for which the peak of the momentum distribution does not correspond to ionization at the peak of the field.

[1] Eckle *et al.*, Science **322**, 1525 (2008).
[2] Arissian *et al.*, Phys. Rev. Lett. **105**, 133002 (2010).

A 26.38 Thu 16:00 P2

Non-linear Compton scattering of ultrashort intense laser pulses — •Daniel Seipt and Burkhard Kämpfer — Institut für Strahlenphysik, Forschungszentrum Dresden Rossendorf, Bautzner Landstraße 400, 01328 Dresden

The Compton scattering of ultrashort intense laser pulses off relativistic electrons is discussed within a framework based on Volkov states. This approach within relativistic quantum electrodynamics fully takes into account the time dependent laser envelope. An expression for the cross section is provided which is independent of the considered pulse shape and pulse length. The ponderomotive broadening of the harmonic peaks, which was predicted within classical calculations of Thomson scattering is confirmed in the Thomson limit of our general quantum result with strong deviations in the high-energy Compton regime. We present a scaling law connecting the first with the latter one, which allows to easily account for recoil effects in classical radiation spectra. Furthermore, we identify regions in phase space, where quantum effects strongly modify the differential photon distribution, even in the Thomson limit.

A 26.39 Thu 16:00 P2

Acceleration of Rydberg atoms in strong laser fields — Thomas Nubbemeyer, •Henri Zimmermann, Sebastian Eilzer, Ulli Eichmann, and Wolfgang Sandner — Max Born Institut, Max Born Str. 2a , 12489 Berlin

Excitation of atoms in strong linearly polarized laser fields in the tunneling regime can be explained within the rescattering model if one includes the Coulomb potential[1]. Furthermore, an unexpectedly strong kinematic force on the surviving neutral atoms during the short laser puls with intensities up to 10^{16}Wcm^2 has been observed and identified as a ponderomotive force acting on the atoms[2]. Here we report on the acceleration of Rydberg atoms in a strong laser fields. In the experiments we excite a Rydberg wave packet with a linearly polarized strong laser field. After a variable time delay covering a range of a few hundred fs before and after the first pulse we apply a second circularly polarized laser pulse to accelerate atoms in excited states. The circularly polarized light alone is not able to excite Rydberg states. We present the results on the deflection of Rydberg atoms, the efficiency of the process including the survival rates of the Rydberg states and on possible wavepacket dynamics associated with the pump probe technique.

[1] Nubbemeyer et al., PRL 101, 233001 (2008).
[2] Eichmann et al., Nature 461, 1261 (2009)

A 26.40 Thu 16:00 P2

Twin-configuration of xenon clusters observed in single shot imaging experiments at FLASH — •D Rupp[1], M Adolph[1], T Gorkhover[1], S Schorb[1,4], H Thomas[1], D Wolter[1], R Hartmann[2], N Kimmel[2], C Reich[2], L Strüder[2], R Treusch[3], T Möller[1], and C Bostedt[1,4] — [1]IOAP, TU Berlin — [2]MPI Hll, München — [3]FLASH/DESY, Hamburg — [4]SLAC, Stanford

Intense, short laser pulses in the x-ray regime from free-electron lasers (FELs) hold great promise for single-shot single-particle imaging down to individual molecules. We performed first scattering experiments on individual free xenon nanoclusters with high intense soft x-ray laser pulses from FLASH-FEL[3] using novel high performance pnCCDs[2].

With less than one cluster in the laser focus, the diffraction patterns revealed three different geometrical configurations. The by far most frequent patterns of concentric rings reflect the event of a single cluster in focus, followed by a double-slit like pattern from a twin cluster configuration with two clusters in direct contact ($\sim 1\%$) and a fine structured interference pattern similar to Newton rings from two clusters one after the other at μm distance ($\sim 0.1\%$).

The twin clusters were so far not expected to be generated in gas expansion sources. Mass spectroscopy is not capable to identify them, only single shot scattering experiments can reveal their presence. Simulations of conceivable parameters as different orientation to the beam, sizes, and degree of fusion allow to explain all observed patterns. We discuss formation schemes and possible experimantal applications of twin clusters.

A 26.41 Thu 16:00 P2

Doppelresonanz-Spektroskopie hoch geladener Ionen — •Manuel Vogel[1], Gerhard Birkl[2], David von Lindenfels[1] und Wolfgang Quint[1] — [1]GSI Darmstadt — [2]TU Darmstadt

Wir präsentieren ein derzeit im Aufbau befindliches Experiment zur hochgenauen Bestimmung der magnetischen Momente des Elektrons und des Atomkerns in hoch geladenen Ionen mittels einer neuartigen Doppelresonanz-Spektroskopie. Diese Methode basiert auf der Speicherung in einer Penning-Falle und erlaubt die rein spektroskopische Messung magnetischer Momente (g-Faktoren) gebundener Elektronen auf dem ppb-Niveau, sowie die gleichzeitige Bestimmung des magnetischen Kernmoments auf dem ppm-Niveau in Abwesenheit diamagnetischer Abschirmung. Dadurch können erstmals neben Rechnungen der QED gebundener Zustände auch entsprechende Modelle der diamagnetischen Abschirmung getestet werden. Das Experiment findet im Rahmen des HITRAP-Projekts am Helmholtz-Zentrum für Ionenforschung statt.

A 26.42 Thu 16:00 P2

Dynamik einer Ionenwolke in einer Penning-Falle bei Kompression durch eine "rotating wall" — •Manuel Vogel[1], Shailen Bharadia[2], Zoran Andjelkovic[1,3], Richard Thompson[2] und Wilfried Nörtershäuser[1,3] — [1]GSI, Darmstadt — [2]Imperial College London — [3]Universität Mainz

Wir präsentieren systematische Messungen zur Dynamik gespeicherter Ionen in einer Penning-Falle, welche durch eine "rotating wall" komprimiert werden. Dazu wurden Ca^+-Ionen in einer Penning-Falle bei Raumtemperatur gespeichert, lasergekühlt und durch Einstrahlung eines rotierenden Dipolfeldes radial komprimiert. Form und Größe (Kompression) der Ionenwolke in der Falle wurden optisch gemessen als Funktion der Fallenparameter und der Parameter der Dipolstrahlung. Für bestimmte Frequenzen der "rotating wall" wurde ein Einbruch der Kompression beobachtet, der durch Aufheizung der Ionenwolke bei ihren Plasma-Frequenzen erklärt werden kann. Das Experiment fand statt vor dem Hintergrund einer "rotating wall" -Anwendung im Rahmen des SPECTRAP-Experiments am HITRAP-Projekt der GSI in Darmstadt. Dort sollen hoch geladene Ionen radial komprimiert werden, um Präzisionsspektroskopie an verbotenen Übergängen zu ermöglichen.

A 26.43 Thu 16:00 P2

A cryogenic Paul Trap for highly charged ions — •Maria Schwarz, Franziska R. Brunner, and José Crespo López-Urrutia — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

An electron beam ion trap (EBIT) is an effective tool for spectroscopy of highly charged ions (HCIs). However, the deep trapping potential leads to high temperatures of the stored ions, and limits the final resolution. A new linear cryogenic Paul-Trap experiment (CryPTEx) inline with an EBIT will provide long storage times for HCIs due to the extremely low background pressure in a 4K enclosure. The device will use sympathetic cooling of the trapped HCIs with laser-cooled singly charged ions to resolve the natural line width of forbidden transitions. In addition, addressing individual ions should eventually become possible, since these arrange themselves in stable Coulomb crystals.

A 26.44 Thu 16:00 P2

Development of a High Current Electron Beam Ion Trap — •Thomas Baumann, José Crespo López-Urrutia, and Joachim Ullrich — Max-Planck-Institut für Kernpyhsik, Heidelberg, Germany

A novel high current electron beam ion trap (EBIT) charge breeder is currently being constructed at the MPI-K Heidelberg in collaboration with the NSCL (MSU) and TRIUMF. The design is based on the TITAN- and FLASH-EBIT, and will utilize an electron gun capable of producing an electron beam of up to 5 A, which is strongly compressed by a 7T magnetic field, to produce and trap highly charged ions from any element. The increased electron beam current will result in an extremely high current density within the trap region that allows for faster charge breeding compared to any other existing EBIT. This enables the new EBIT to produce He-, H-like or bare ions of heavy elements in hundreds of ms. These ions can be studied within the EBIT by various spectroscopic instruments or being extracted to further experiments. First performance tests of the EBIT are presented. Furthermore the machine allows for the study of charge state optimization and a further reduction of charge breeding times which will support the development of future EBIT charge breeders.

A 26.45 Thu 16:00 P2

Angular correlations in the two-photon decay of helium-like heavy ions — A. Surzhykov[1,2], A Volotka[3], F. Fratini[1,2], J.P. Santos[4], P. Indelicato[5], T. Stöhlker[1,2], and •S. Fritzsche[2,6] — [1]Physikalisches Institut, Universität Heidelberg, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung, Germany — [3]Technische Universität Dresden, Germany — [4]Departamento de Física, Universidade Nova de Lisboa, Portugal — [5]Laboratoire Kastler Brossel, Paris, France — [6]Department of Physics, University of Oulu, Finland

The two-photon decay of high-Z, helium–like ions has been studied theoretically in the framework of second-order perturbation theory and the Dirac equation, with emphasis placed especially on the angular emission of the two photons. In this work, we explored how the angular correlation function depends on the shell structure of the ions in their initial and final states as well as how the terms beyond the electric-dipole approximation affect the angular emission. Detailed calculations were performed for the two–photon decay of the $1s2s\,^1S_0$, $1s2s\,^3S_1$ and $1s2p\,^3P_0$ states of helium-like xenon Xe^{52+}, gold Au^{77+} and uranium U^{90+} ions. Our results display a strong dependence of the photon emission pattern with regard to the symmetry and parity of initial and final ionic states [1].

[1] A. Surzhykov et al., Phys. Rev. A **81** (2010) 042510.

A 26.46 Thu 16:00 P2

Precision Spectroscopy of Trapped Radium Ions — J.E. van den Berg, •G.S. Giri, D.J. van der Hoek, S.M. Hoekman, S. Hoekstra, K. Jungmann, W.L. Kruithof, M. Nunez-Portela, C.J.G. Onderwater, E.B. Prinsen, B.K. Sahoo, B. Santra, M. Sohani, P.D. Shidling, R.G.E. Timmermans, O.O. Versolato, L.W. Wansbeek, L. Willmann, and H.W. Wilschut — Kernfysisch Versneller Instituut, University of Groningen, The Netherlands

Radium ion is an ideal candidate for high precision experiments. Atomic Parity Violation (APV) can be measured in a single trapped and laser cooled Ra^+, enabling a precise measurement of the electroweak mixing angle in the Standard Model of particle physics at the lowest possible momentum transfer. Ultra-narrow transitions in this system can also be exploited to realize a high stability frequency standard. As an important step towards such high precision experiments, excited-state laser spectroscopy is being performed with trapped short-lived $^{209-214}Ra^+$ ions. The results on hyperfine structure, isotope shift and lifetime provide benchmark for the required atomic theory. The experimental set up to perform laser cooling of the trapped radium ions and trapping of a single radium ion is under way.

A 26.47 Thu 16:00 P2

Laser Spectroscopy of Radium — •Bodhaditya Santra, Umakanth Dammalapati, Klaus Jungmann, and Lorenz Willmann — KVI, University of Groningen

Searches for permanent electric dipole moments (EDMs) of fundamental particles are sensitive probes of physics beyond the Standard Model. Fundamental EDMs can experience enhancements in atomic and molecular systems. In particular, isotopes of the heavy alkaline earth element radium exhibit the largest known enhancement factors for any atomic systems due to their atomic and nuclear structure. A sensitive search for EDMs will require an efficient use of the rare isotops, which are available from radioactive sources or at rare isotope facilities like TRIμP at KVI. Here, laser cooling and trapping methods play a crucial role. The main transitions from the ground state have been identified by laser spectroscopy. Nevertheless, the strongest cooling transitions $7s^2\ ^1S_0$ - $7s7p\ ^1P_1$ suffers from strong leakage to metastable states, similar to the case of barium. We describe the experimental approach to determine the wavelength of the three needed repump transitions, which then will permit an efficient capture of radium atoms into a magneto optical trap.

A 26.48 Thu 16:00 P2

Absolute frequency measurement of Rubidium Rydberg transitions — •Markus Mack, Florian Karlewski, Helge Hattermann, Florian Jessen, Simone Höckh, Daniel Cano, and József Fortágh — Physikalisches Institut der Universität Tübingen, Center for Collective Quantum Phenomena and their Applications

We present absolute frequency measurements of ^{87}Rb $5S_{1/2}F=2 \rightarrow 5P_{3/2}F=3 \rightarrow$ nS and nD Rydberg transitions. These measurements were taken by observing electromagnetically induced transparency in a vapor cell as well as in a MOT. We report on our experimental setup, the results, and possible applications.

A 26.49 Thu 16:00 P2

Critical analysis of the methods of interpretation in the hyperfine structure of free atoms and ions. Case of the even configuration system of the titanium atom — •Jerzy Dembczyński, Magdalena Elantkowska, and Jarosław Ruczkowski — Chair of Quantum Engineering and Metrology, Faculty of Technical Physics, Poznan University of Technology, Nieszawska 13B, 60-965 Poznan, Poland

On the basis of experimental data, the even configuration system in the titanium atom was analyzed. Our investigations indicate that the operator

$$H_{\rm hfs} = \sum_{K=1}^{3} T_e^{(\kappa k)K} \cdot T_n^{(K)}$$

describes the partition of the observed hyperfine splittings into the contributions of ranks K=1,2 and 3 within the experimental accuracy, while the operator

$$T_e^{(\kappa k)1} \cdot T_n^{(1)} =$$

$$\frac{\mu_0\mu_B}{2\pi}\sum_{i=1}^{N}\left[\widehat{l_i}\left\langle r^{-3}\right\rangle^{01} - \sqrt{10}\left(\widehat{s}_i\widehat{C}_i^2\right)^{(1)}\left\langle r^{-3}\right\rangle^{12} + \widehat{s}_i\left\langle r^{-3}\right\rangle^{10}\right]\cdot T_n^{(1)}$$

does not fully account for the partition of the interactions of rank K=1 into contributions κk = 01,12 and 10.

This work was supported by Politechnika Poznańska under the project DS-63-029/2011

A 26.50 Thu 16:00 P2

Investigation of the hfs splittings in chromium atom by LIF and ABMR-LIRF methods — Andrzej Krzykowski, •Przemysław Głowacki, Andrzej Jarosz, and Jerzy Dembczyński — Chair of Quantum Engineering and Metrology, Poznań University of Technology, ul. Nieszawska 13B, 60-965 Poznań, Poland

Due to a small amount of experimental data concerning the hfs (hyperfine structure) of chromium atom available in the literature, our research group undertook a systematic study on this element. Our investigations were performed on an atomic beam apparatus by the LIF method (laser induced fluorescence) and ABMR-LIRF method (atomic beam magnetic resonance, detected by laser induced resonance fluorescence). For the electron levels belonging to the multiplet 3d^{5}4s a ^{5}P it was possible to obtain the values of the hfs intervals with the accuracy of about 1 kHz. This allowed us to determine precisely the values of the hfs constants A and B, representing magnetic dipole and electric quadrupole interactions. Additionally, for the presented levels the estimation of the value of the hfs constant C (magnetic octupole interaction) was made.

This work was performed within the framework of DS63-029/11.

A 26.51 Thu 16:00 P2

Entwicklungen zur direkten Bestimmung des g-Faktors eines einzelnen Protons — •Cricia Rodegheri[1], Klaus Blaum[2,3], Holger Kracke[1], Andreas Mooser[1], Wolfgang Quint[4], Stefan Ulmer[1,2,4] und Jochen Walz[1] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz — [2]Max-Planck-Institut für Kernphysik, 69117 Heidelberg — [3]Ruprecht-Karls-Universität, 69047 Heidelberg — [4]GSI Darmstadt, 64291 Darmstadt

Ein Überblick zur Messung des g-Faktors eines einzelnen, isolierten Protons in einer zylindrischen Doppel-Penningfalle 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 gemäβ $g = 2\frac{\nu_L}{\nu_c}$ berechnen, wobei ν_c die freie Zyklotronfrequenz bezeichnet, welche über die Eigenfrequenzen in der sogenannten Präzisionsfalle bestimmt wird. Die Larmorfequenz ν_L wird über eine Spinflipresonanz ermittelt. Die Detektion des Spinzustandes erfolgt in der sogenannten Analysefalle, in die durch eine ferromagnetische Ringelektrode ein starker magnetischer Quadrupol von 300 mT/mm^2 eingebracht wird. Der Nachweis eines Protons unter diesen extremen magnetischen Bedingungen wird präsentiert.

A 26.52 Thu 16:00 P2

Laser spectroscopy of evaporatively cooled highly charged ions at the Heidelberg Electron Beam Ion Trap — •Volkhard Mäckel, Renee Klavitter, Günter Brenner, José Ramón Crespo López-Urrutia, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

We report on two level laser fluorescence measurement of the forbidden $1s^22s^22p$ $^2P_{3/2}$-$^2P_{1/2}$ M1 transition in boron-like Ar^{13+} at the Heidelberg Electron Beam Ion Trap. The transition was resonantly excited using a tunable pulsed dye laser while simultaneously monitoring the fluorescence photons, yielding a wavelength of 441.25575(17) nm. Forced evaporative cooling on the trapped ions yielded a resolving power of $\lambda/\delta\lambda$=15000, thus being able to resolve the Zeeman splitting of the transition due to the magnetic field present in the trap. This approach in combination with further cooling and two-photon excitation techniques can yield for far more accurate transition energies in highly charged ions than currently possible, pointing toward new precision optical frequency standards based upon highly charged ions.

A 26.53 Thu 16:00 P2

Das 0°-Spektrometer für den Frankfurter Niederenergie-Speicherring (FLSR) — •Annika Jung, Kurt Ernst Stiebing, Lothar Ph. H. Schmidt, Reinhard Dörner, Thomas Felix, Thomas Kruppi, Steffen Enz und Marco Völp — Institut für Kernphysik der Goethe Universität Frankfurt, Max von Laue Straße 1, 60438 Frankfurt a.M.

Am Institut für Kernphysik an der Goethe Universität Frankfurt wird derzeit ein elektrostatischer Speicherring für Ionen bis zu einer Energie von 50 keV aufgebaut (Frankfurt Low Energy Storage Ring - FLSR[1]). Zur Spektroskopie der Lebensdauern der Ionen wird ein Spektrometer benötigt, welches die neutralisierten Ionen unter 0° nachweist (0°-Spektrometer). Im Rahmen dieser Arbeit wurde ein solches Spektrometer aufgebaut und in Betrieb genommen. Im Beitrag werden erste Messungen vorgestellt. [1] K.E. Stiebing et al. Nucl. Instr. And Meth A 614 (2010) 10-16

A 26.54 Thu 16:00 P2

Direct Determination of the Magnetic Quadrupole Contribution to the Lyman-α_1 Transition in a Hydrogen-like Ion — •Günter Weber[1,2,3], Harald Bräuning[1], Andrey Surzhykov[1,3], Stephan Fritzsche[1,4], Siegbert Hagmann[1], Renate Märtin[1,3], Regina Reuschl[1], Uwe Spillmann[1], Sergiy Trotsenko[1,2], Danyal Winters[1], and Thomas Stöhlker[1,2,3] — [1]GSI, Darmstadt, Germany — [2]Helmholtz-Institut Jena, Germany — [3]Physikalisches Institut, Universität Heidelberg, Germany — [4]Department of Physics, University of Oulu, Finland

By applying novel-type position sensitive x-ray detectors as Compton polarimeters we performed the first linear polarization measurement of the Lyman-α_1 radiation (2p$_{3/2}$ -> 1s$_{1/2}$) in a high-Z system, namely in U^{91+}. Here, we observed an interference between the electric-dipole (E1) and the magnetic-quadrupole (M2) tranistion amplitudes leading to a significant depolarization of the Lyman-α_1 radiation. In the present work, we show that a combined measurement of the linear polarization and of the angular distribution enables a very precise determination of the ratio of the E1 and the M2 amplitudes and the corresponding transition rates without any assumptions concerning the population mechanism for the excited 2p$_{3/2}$ state. This finding opens a new route to disentangle the population process of the excited ionic state from the subsequent decay properties. The accuracy of the obtained amplitude ratio will stimulate more detailed quantum-electrodynamical investigations on the transition amplitudes of highly-charged ions beyond Dirac's theory.

A 26.55 Thu 16:00 P2

Röntgenspektroskopische Untersuchungen an hochgeladenen Schwerionen — •Alexander Mayr[1,2], Joachim Jacoby[1], Thomas Kühl[2] und Olga Rosmej[2] — [1]Institut für Angewandte Physik, Goethe-Universität Frankfurt am Main — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt

Die Energien bestimmter Innerschalenübergänge hochgeladener (lithiumähnlicher) Ionen erlauben die direkte experimentelle Bestimmung verschiedener quantenmechanischer Zustandsgrößen, wie Kernspin oder Ladungsradien. Die präzise spektroskopische Bestimmung dieser Energien erlaubt die Überprüfung theoretischer Vorhersagen der QED, die bislang noch nicht ausreichend untermauert sind. Am GSI Helmholtzzentrum (Darmstadt), wird ein solches Spektroskopieexperiment über die Wechselwirkung eines Schwerionenstrahls mit einem Rötgenlaser realisiert. Eine Herausforderung ist dabei die Entwicklung geeigneter Detektorsysteme, die im Energiebereich einiger hundert eV eine besonders hohe Effizienz besitzen müssen. An einer hierfür konstruierten Testquelle wurden dazu verschiedene Untersuchungen zu möglichen Detektionsverfahren durchgeführt. Der vorliegende Beitrag gibt einen Überblick über das Spektroskopieexperiment und behandelt die bisher durchgeführten Experimente zur Realisierung des Röntgenlasers und des Detektors.

A 26.56 Thu 16:00 P2

New energy levels of Praseodymium with large angula momentum — •Shamim Khan, Imran Siddiqui, Bettina Gamper, Tanweer Iqbal Syed, Günter H. Guthöhrlein, and Laurentius Windholz — Inst. f. Experimentalphysik, Techn. Univ. Graz, Petersgasse 16, A-8010 Graz

The electronic ground state configuration of praseodymium $^{59}Pr_{141}$ is [Xe] $4f^3 6s^2$, with ground state level $^4I_{9/2}$. Our research is mainly devoted to find previously unknown energy levels by the investigation of spectral lines and their hyperfine structures. In a hollow cathode discharge lamp praseodymium atoms and ions in ground and excited states are excited to high lying states by laser light. The excitation source is a tunable ring-dye laser system, operated with R6G, Kiton Red, DCM and LD700. A high resolution Fourier transform spectrum is used for selecting promising excitation wavelengths. Then the laser wavelength is tuned to a strong hyperfine component of the spectral line to be investigated, and a search for fluorescence from excited levels is performed. From the observed hyperfine structure we determine J-values and hyperfine constants A of the combining levels. This information, together with excitation and fluorescence wavelengths, allows us to find the energies of involved new levels. Up to now we have discovered large number of previously unknown energy levels with various angular momentum values. We present here the data (energies, parities, angular momenta J, magnetic hyperfine constants A) of ca. 40 new, until now unknown energy levels with high angular momentum values: 15/2, 17/2, 19/2, 21/2.

A 26.57 Thu 16:00 P2

Hyperfine structure measurements and discovery of new energy levels in neutral Praseodymium — •Siddiqui Imran, Shamim Khan, Tanweer Iqbal Syed, Bettina Gamper, and Laurentius Windholz — Inst. f. Experimentalphysik, Techn. Univ. Graz, Petersgasse 16, A-8010 Graz

We present here 14 even and 17 odd parity new energy levels of the neutral praseodymium atom. Free praseodymium atoms in ground and excited states are produced in a hollow cathode discharge lamp by cathode sputtering. The hyperfine structure (hfs) of the spectral lines is investigated by the method of laser induced fluorescence (LIF) spectroscopy. As an example of the method used we discuss briefly the finding of the new level at 27304.431 cm^{-1}, even parity, J = 9/2 and A = 690(1) MHz. Laser excitation of the line at 6004.23 is performed and a LIF signal is detected at fluorescence lines 5246.709, 5412.95, 5925.10, 6107.88, 6287.02, 6419.16, and 6620.63 . The hfs is then recorded digitally and fitted to find reliable values of angular momentum J, magnetic and electric quadrupole hyperfine constants A and B for the combining fine structure levels. Assuming an unknown upper level, a lower level is searched in the data base of known levels, having the J and A values determined from the fit procedure. A level with 10654.11 cm^{-1}, odd parity, J = 7/2 and A = 169(2) MHz is found. The energy of the upper level is calculated by adding the center of gravity wave number of the excited line to the energy of the lower level. The existence of the new level is checked by at least one additional laser excitation from another known lower level.

A 26.58 Thu 16:00 P2

Comparison between measurements of hyperfine structures of Pr II - lines investigated by collinear laser ion beam spectroscopy (CLIBS) ans saturation spectroscopy — •Nadeem Akhtar[1,2], Naveed Anjum[1,2], Harry Hühnermann[1,3], and Laurentius Windholz[1] — [1]Inst. f. Experimentalphysik, Techn. Univ. Graz, Petersgasse 16, A-8010 Graz — [2]Optics Labs, Nilore, Islamabad, Pakistan — [3]Fachbereich Physik, Univ. Marburg/Lahn

Investigation of narrow hyperfine structures needs a reduction of the Doppler broadening of the investigated lines. Here we have used two methods: collinear laser spectroscopy (CLIBS) and laser saturation spectroscopy. In the first method, the Doppler with is reduced by accelerating Pr ions to a high velocity and excitation with a collinear laser beam, while in the second method ions with velocity group zero are selected by nonlinear saturation.

In this work the hyperfine spectra of several Pr II lines were investigated using CLIBS. A line with of ca. 60 MHz was measured. The same lines were then investigated in a hollow cathode discharge lamp using intermodulated laser-induced fluorescence spectroscopy. Using this technique a spectral line width of about 200 MHz was achieved. In both methods, the excitation source is a ring dye laser operated with R6G. Using a fit program, magnetic dipole interaction constants A and the electric-quadrupole interaction constants B of the involved levels have been determined in both cases. We discuss advantages and disadvantages of both methods.

A 26.59 Thu 16:00 P2

New even parity energy levels of Pr I found by excitation of transitions in the region 560 - 695 nm — •Tanweer Iqbal Syed, Shamim Khan, Siddiqui Imran, Uddin Zaheer, and Laurentius Windholz — Inst. f. Experimentalphysik, Techn. Univ. Graz, Petersgasse 16, A-8010 Graz

The knowledge of electronic levels is essentially needed for a description of the interactions between the electrons of an atom and for the classification of an atomic spectrum. We have studied the hyperfine structure of Praseodymium spectral lines in the region from 560 to 695 nm. The hyperfine structure of a large number of unclassified Pr I - lines have been investigated by using the method of laser induced fluorescence in a hollow cathode discharge. During this investigation, we have discovered twelve energy levels with even parity, which were previously unknown. The excitation source was a ring dye laser operated with R6G, Kiton red, or DCM. J-quantum numbers and magnetic dipole interaction constants A for upper and lower levels have been determined from the recorded hyperfine structures. The energies of new levels have been determined by using these constants, excitation and fluorescence wavelengths. Promising excitation wavelengths have been taken from Fourier transform spectra. The new levels were confirmed by at least one second laser excitation.

A 26.60 Thu 16:00 P2

Combine a Magneto-Optical Trap with a Magnetic Trap for ^7Li Atoms — •Christoph Schreyvogel, Matthias Strebel, Frank Stienkemeier, and Marcel Mudrich — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, D-79104 Freiburg

We utilize a magneto-optical trap (MOT) in combination with a decreasing field type Zeeman-slower to generate an ultracold cloud of ^7Li-Atoms for future scattering experiments (reactive and non-reactive collisions) with cold molecules produced by means of supersonic expansion out of a rotating nozzle. A special feature of our MOT-apparatus is the implementation of a magnetic trap with high field-gradients for trapping the atoms in the electronic ground state at high density. With this setup we will study reactive collisions, such as $Li + HF \rightarrow LiF + H$ at collision energies down to $\leq 1meV$ from which we expect to get insight into the quantum mechanical nature of cold reaction dynamics. The required laser-system for the magneto-optical trap and Zeeman-slower is based on a "master-slave-slave" scheme. The master laser is a low-power single-mode diode laser which is used for injection-locking of two slave-lasers which in turn are used for injection-locking of two additional slave diode lasers to produce high-power narrowband radiation for the MOT-operation.

A 26.61 Thu 16:00 P2

3D-self-trapping of Rydberg-dressed BECs — •Nils Henkel[1], Fabian Maucher[1], Stefan Skupin[1,2], and Thomas Pohl[1] — [1]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden — [2]Friedrich Schiller University, Institute of Condensed Matter Theory and Optics, 07743 Jena

We demonstrate that optical coupling of Bose-Einstein condensates can lead to the formation of stable three-dimensional bright solitons, bound by a single pair of Rydberg atoms. It is shown that off-resonant dressing with Rydberg d-states of Rubidium provides an anisotropic but attractive long range interaction which could enable the first realization of such three-dimensional structures. Taking into account both the long range interaction and the short range contact interaction between groundstates, we find large self-trapped three-dimensional solitons for realistic experimental parameters and study their stability.

A 26.62 Thu 16:00 P2

Excitation dynamics of bosons with driven interaction in harmonic trap — •Ioannis Brouzos and Peter Schmelcher — ZOQ Hamburg

We investigate the excitation properties of finite bosonic systems in a one-dimensional harmonic trap with time-dependent interaction. Periodically oscillating driving of the interparticle interaction strength induces excitations of relative motion of the many-body state with particular and controlable contributions of momentarily excited states, and mechanisms for quantum acceleration in the case of resonances occur. For the case of the relative coordinate sytem of two particles, we show the main excitation mechanisms, the role of driving frequency and strength and initial correlation of the bosonic state are discussed, while the Floquet spectrum is calculated revealing the acceleration modes. This simple case is used then for the bottom-up understanding of cases with higher particle numbers, and offers the possibility to design excitations of the many-body state exclusively in the relative motion.

A 26.63 Thu 16:00 P2

Feshbach Spectroscopy of Sodium and Sodium-Lithium — •Raphael Scelle, Tobias Schuster, Arno Trautmann, Steven Knoop, and Markus K. Oberthaler — Kirchhoff Institut für Physik, Universität Heidelberg, Im Neuenheimer Feld 227, 69120 Heidelberg

We present our experimental setup for the creation of an ultracold Bose-Fermi mixture of ^{23}Na and ^{6}Li. In our first experiments we observed several new Na intraspecies and Na-Li interspecies Feshbach resonances, with the highest resonances located above 2kG. Our precise and extensive Feshbach spectroscopy of sodium up to g-wave resonances allows for a better determination of the Na-Na interaction potentials. The observed Na-Li spectrum at high magnetic fields deviates significantly from the previously predicted one and we propose an alternative scenario based on the Asympotic Bound-state Model.

A 26.64 Thu 16:00 P2

A transportable setup for high resolution measurements of ion-atom collisions — •Simone Götz[1], Bastian Höltkemeier[1], Thomas Amthor[1], Alexey Sokolov[2], Wolfgang Quint[2], and Matthias Weidemüller[1] — [1]Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt

We present a transportable setup combining a magneto-optical trap for rubidium atoms with a recoil ion momentum spectrometer. After interaction of the trapped atoms with highly charged ions the recoil ion momentum can be measured with very high precision due to the very low thermal spread of the target atoms. In collaboration with the GSI in Darmstadt we will investigate correlation effects in multiple charge transfer between the rubidium atoms and highly charged ions. We will discuss several improvements of this setup, including a new recoil ion momentum spectrometer with enhanced optical access and a new technique to calibrate the spectrometer by producing a high rate of short ion pulses from the trapped atoms based on an LED.

A 26.65 Thu 16:00 P2

Single particle and bound state condensation in interacting Bose gases — •Michael Maennel[1,2], Klaus Morawetz[1,3], Pavel Lipavsky[4,5], and Michael Schreiber[2] — [1]Department Physical Engineering, Münster University of Applied Science, 48565 Steinfurt, Germany — [2]Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz, Germany — [3]International Institute of Physics, Universidade Federal do Rio grande do Norte, 59.072-970 Natal-RN, Brazil — [4]Institute of Physics, Academy of Sciences, 16253 Prague 6, Czech Republic — [5]Faculty of Mathematics and Physics, Charles University, 12116 Prague 2, Czech Republic

We investigate a Bose gas with finite-range interaction using a scheme to eliminate self interaction in the T-matrix approximation. In this way the corrected T-matrix becomes suitable to calculate properties below the critical temperature, without the use of anomalous functions. We calculate the phase diagram, excitation spectrum and equation of state. For attractive interaction, an Evans-Rashid transition occurs between a quasi-ideal Bose gas and a BCS-like phase. In the latter there is a condensation of bound states resulting in a gap in the excitation spectrum. The gap decreases with increasing density and vanishes at the critical density for Bose-Einstein condensation, where the single-particle dispersion becomes linear for small momenta. The investigation of the equation of state indicates however, that the mentioned phase transitions might be inaccessible due to a preceding liquefaction.

A 26.66 Thu 16:00 P2

Self-rephasing of a cold atomic ensemble for extended coherence times — •Christian Deutsch[1], Fernando Ramirez-Martinez[2], Wilfried Maineult[2], Clement Lacroûte[2], Friedemann Reinhard[1], Jean-Noël Fuchs[3], Fréderic Piéchon[3], Franck Laloë[1], Jakob Reichel[1], and Peter Rosenbusch[2] — [1]LKB - Ecole Normale Supérieure - UPMC - CNRS - Paris — [2]SYRTE - Observatoire de Paris - UPMC - CNRS - Paris — [3]Laboratoire de Physique des Solides- Univ. Paris-Sud - CNRS - Orsay

We report on the observation of very long coherence times on ultracold trapped 87Rb atoms. The experiment[1] is designed to operate a microwave atomic clock in the $10^{-13}s^{-1/2}$ stability regime in a compact setup. The spatial inhomogeneities of Zeeman and collisional shift are largely compensated. Remaining field inhomogeneities limit the frequency spread to $<$ 80mHz giving rise to dephasing of the individual atoms on a timescale of 2 to 3 s [2]. Surprisingly the coherence time is more than an order of magnitude larger than expected.

We explain this by a rephasing of the atomic spins driven by the Identical Spin Rotation Effect[3] acting as a continous spin echo. The interaction effect is demonstrated by tuning the atom density and thereby the ISRE rate[4].

The effect is very general in nature and should be observable in a multitude of systems.

[1] IEEE TUFFC 56, 106 (2010), [2] Appl Phys B 95, 227 (2009), [3] Phys Rev. Lett. 102, 215301 (2009), [4] Phys Rev Let 105, 2, 020401 (2010)

A 26.67 Thu 16:00 P2

Impact of anisotropy on vortex clusters and their dynamics — •Jan Stockhofe[1], Stephan Middelkamp[1], Panayotis G. Kevrekidis[2], and Peter Schmelcher[1] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Department of Mathematics and Statistics, University of Massachusetts, Amherst MA 01003-4515, USA

We investigate the effects of anisotropy on the stability and dynamics of vortex cluster states which arise in Bose-Einstein condensates.

Sufficiently strong anisotropies are shown to stabilize states with arbitrary numbers of vortices that are highly unstable in the isotropic limit. Conversely, anisotropy can be used to destabilize states which are stable in the isotropic limit.

Near the linear limit, we identify the bifurcations of vortex states including their emergence from linear eigenstates, while in the strongly nonlinear limit, a particle-like description of the dynamics of the vortices in the anisotropic trap is developed. Both are in very good agreement with numerical results.

Collective modes of stabilized many vortex cluster states are demonstrated.

A 26.68 Thu 16:00 P2

d-wave confinement-induced resonances in harmonic waveguides — •Panagiotis Giannakeas[1], Vladimir S. Melezhik[2], and Peter Schmelcher[1] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Germany — [2]Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, Dubna, Russian Federation

It is demonstrated that low energy pair collisions of bosonic atoms with isotropic interatomic interaction in harmonic waveguides can lead to coupled s- and d-wave confinement-induced resonances (CIRs). In analogy to the extensively studied s-wave case, we show that the d-wave CIR effect emerges in the quasi-1D regime of the confining trap as an imprint of the 3D d-wave resonant scattering properties. The presence of the centrifugal barrier for higher partial waves modifies the confinement strength dependence of the resonant condition, which is determined for the parameters of the applied model. The effect can be utilized for the realization of confined atomic gases interacting via higher partial waves and opens a novel possibility for studying such correlated atomic systems.

A 26.69 Thu 16:00 P2

Immersing Single Atoms into Cold and Ultracold Gases — •Farina Kindermann[1], Shincy John[1], Nicolas Spethmann[1], Amir Moqanaki[1], Claudia Weber[1], Dieter Meschede[1], and Artur Widera[2,1] — [1]Institut für Angewandte Physik, Wegelerstr. 8, 53115 Bonn — [2]Technische Universität Kaiserslautern, Fachbereich Physik, Erwin-Schrödinger-Str., 67663 Kaiserslautern

We immerse single Cs atoms into a many body systems consisting of cold and ultracold Rb gases in order to use the single Cs atom as a sensitive probe for inter-species interaction and as an agent to manipulate the quantum gas.

From a UHV-MOT Rb is loaded into a magnetic trap. In this trap, the Rb ensemble is precooled by microwave evaporation to approximately $1\mu K$. Using a magnetic transport guided by a dipole trap, the Rb is moved to the center of the quadrupole coils and loaded into a crossed dipole trap. In this crossed dipole trap, further evaporation to quantum degeneracy is performed. Using rf and microwave fields, the Rb is prepared in the magnetic insensitive $F = 0$, $m_F = 0$ state. This enables the use of a high gradient MOT to capture single Cs atoms from the background gas. The overlap between both systems can be adjusted by optimizing the interaction between Cs atoms in the MOT and Rb atoms in the dipole trap. From the MOT, single Cs atoms are loaded into an one-dimensional lattice. Finally, the groundstate collisions between single Cs atoms and Rb gas can be studied in the conservative potential formed by the combination of the lattice and the dipole trap.

A 26.70 Thu 16:00 P2

Towards an Erbium BEC — •Albert Frisch[1], Johannes Schindler[1], Alexander Rietzler[1], Rudolf Grimm[1,2], and Francesca Ferlaino[1] — [1]Institut für Experimentalphysik, Universität Innsbruck, 6020 Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, 6020 Innsbruck, Austria

Over the last years, the frontiers of ultracold quantum gases have been enlarged to new non-alkali atomic species, opening up intriguing possibilities for a variety of novel applications. We propose to produce and study quantum gases of erbium atoms. Erbium (Er) is an extremely heavy (166 a.u.) and strongly magnetic ($7\,\mu_B$) rare-earth atom with a rich isotopic variety and a complex energy level structure. The unique combination of interesting properties allows studies of dipolar effects where the anisotropic and long-range dipole-dipole interactions dominate over the simple isotropic contact interaction. With Er Feshbach molecules a more extreme situation can be achieved where the strength of the dipole-dipole interaction even gets comparable to the one between ground-state polar molecules. We present the latest progresses of our Er machine. These include spectroscopic measurements on the strongest cooling transition at 401 nm. The isotope shift has been determined and the hyperfine structure of the fermionic isotope ^{167}Er has been resolved. Measurements on the velocity distribution after the Zeeman slower will show us the best strategy for directly loading the atoms into a narrow-linewidth magneto-optical trap operating on the 170 kHz broad transition at 583 nm.

A 26.71 Thu 16:00 P2

Ultracold Fermi-Fermi Mixtures: The ^{6}Li-^{40}K System — •Frederik Spiegelhalder, Antje Ludewig, Tobias Tiecke, and Jook Walraven — Van der Waals-Zeeman Instituut, Universiteit van Amsterdam, Netherlands

Fermi-Fermi systems, in particular ^{6}Li-^{40}K, are currently studied in great detail both theoretically as well as experimentally. We now understand the basic scattering properties of the Li-K system. Several interspecies Feshbach resonances have been found and characterized [1, 2]. Heteronuclear molecules have been created at various resonances [3, 4]. Still many effects only observable in a mass-imbalanced system have not been experimentally achieved, yet. One significant difference to the single-species experiments is the possibility to apply species-specific optical trapping potentials [5]. Several theoretical proposals suggest that by confining one species using species-selective optical lattices, interesting new phases could be realized [7]. For example, a long-lived universal trimer state is expected to be observed in a mixed-dimensional system [6]. Here we present our recent experimental efforts towards realising a mixed-dimensional system.

[1] Wille et al. Phys. Rev. Lett. 100 (2008) 053201
[2] Tiecke et al. Phys. Rev. Lett. 104 (2010) 053202
[3] Spiegelhalder et al. Phys. Rev. A 81 (2010) 043637
[4] Voigt et al. Phys. Rev. Lett. 102 (2009) 020405
[5] LeBlanc and Thywissen. Phys. Rev. A 75 (2007) 053612
[6] Levinsen et al. Phys. Rev. Lett. 103 (2009) 153202
[7] Nishida and Tan. Phys. Rev. Lett. 101 (2008) 170401

A 26.72 Thu 16:00 P2

Many-body effects for cold atoms in line-centered lattices — •Gediminas Juzeliunas[1], Tomas Andrijauskas[1], Congjun Wu[2], and Maciej Lewenstein[3,4] — [1]Institute of Theoretical Physics and Astronomy, Vilnius University, A. Goštauto 12, LT-01108 Vilnius, Lithuania — [2]Department of Physics, University of California, San Diego, California 92093, USA — [3]ICFO-Institut de Ciencies Fotoniques, Parc Mediterrani de la Tecnologia, E-08860 Castelldefels (Barcelona), Spain — [4]ICREA - Institucio Catalana de Recerca i Estudis Avancats, 08010 Barcelona, Spain

Recently a line-centered lattice has been proposed and analyzed for cold atoms [1]. A distinguished feature of such a lattice is that its dispersion contains a Dirac cone intersecting with a completely flat band [1]. Here we analyze effects of the atom-atom interaction of the Hubbard type for the line-centered lattice. The lattice is populated by fermionic atoms in two different internal states. We show that there are localized eigen-solutions of the non-interacting Hamiltonian which are preserved by including a sufficiently small atom-atom interaction. The situation resembles to a certain degree the one appearing in the p-band honeycomb lattice in which the interaction takes place between two different atomic p-states [2]. Yet in the present case we are dealing with the s-band of the line-centered lattice, and the interaction takes place between the atoms in different internal states.

[1] R. Shen et al. Phys. Rev. B 81, 041410 (2010). [2] C. Wu et al, Phys. Rev. Lett. 99, 070401 (2007).

A 26.73 Thu 16:00 P2

***Ab-initio* time-dependent investigation of two ultracold atoms in optical lattices** — •Philipp-Immanuel Schneider and Alejandro Saenz — AG Moderne Optik, Humboldt-Universität zu Berlin, Newtonstraße 15, 12489 Berlin

Ultracold atoms in optical lattices and superlattices are good candidates for performing quantum information processing but also for studying fundamental phenomena such as quantum entanglement and transport. We are developing an *ab-initio* approach to solve the full time-dependent Schrödinger equation for two interacting atoms in two or three wells of a 3-dimensional optical lattice. We allow for various time-dependent perturbations of the lattice that correspond, e.g., to a shaking of the lattice or the lowering of the barrier between two lattice sites. Furthermore, the atoms can interact via realistic Born-Oppenheimer potentials or one can simulate the appearance of broad and narrow Feshbach resonances. We are going to present the numerical approach and first studies of several time-dependent processes.

A 26.74 Thu 16:00 P2

A study of CPT resonances in an optical dipole trap — •Carl Basler, Alexander Lambrecht, Florian Meinert, and Hanspeter Helm — Physikalisches Institut, Universität Freiburg, Germany

A table-top atomic clock based on coherent population trapping (CPT) resonances with parallel linearly polarized optical fields in a vapor cell has recently been demonstrated on the D1 line of Rb87[1]. We study this transition with counter-propagating laser beams in an optical dipole trap. One goal is to explore the suitability of this transition for an all optical path to continuous generation of low temperature trapped atom samples using the proposed EIT-cooling scheme [2,3]. Due to the low trapping frequencies which can be realized for neutral atoms, a magnetic-field insensitive CPT resonance transition appears paramount to success. A second attractive feature of this transition is the high contrast of the resonance amplitude[1]. The experiment is carried out using two externally phase-locked diode lasers and a crossed CO2 laser dipole trap which is loaded from a 2D-MOT. Research supported by Research supported by DFG HE2525/7

1 E. E. Mikhailov et al.
2 C. Morigi, Phys. Rev. A. 67 033402 (2003)
3 M. Roghani et al. Phys. Rev. A 81 033418 (2010)

A 26.75 Thu 16:00 P2

Towards Ultracold Mixtures on a Chip — •Sonali Warriar, Matthew Jones, Asaf Paris-Mandoki, Gal Aviv, Anton Piccardo-Selg, German Sinuco, Thomas Fernholz, Lucia Hackermuller, and Peter Kruger — University of Nottingham, Nottingham, UK

Ultracold mixtures hold the promise of understanding new phases of matter and collisions at very low energies. We are setting up experiments with lithium and cesium mixtures on a chip i.e, ^{6}Li - ^{7}Li mixtures, heteronuclear LiCs or homonuclear $^6Li_2$ molecules. By combining the capabilities of the atom chip with optical dipole trapping, it will be possible to trap these mixtures in low dimensions and tune their scattering lengths via Feshbach resonances. In this way, it will also be possible to realise experiments with additional magnetic potentials or investigate cold atoms interacting with a 2D electron gas. Here we present the current status of our experiment.

A 26.76 Thu 16:00 P2

Theory of photoassociation of ultracold trimers: long-range interactions — Maxence Lepers[1], Romain Vexiau[1], Nadia Bouloufa[1], Viatcheslav Kokoouline[2,1], and •Olivier Dulieu[1] — [1]Laboratoire Aimé Cotton, CNRS/Université Paris-Sud, Orsay, France — [2]Department of Physics, University of Central Florida, Orlando, Fl, USA

The electrostatic interaction between an excited atom and a diatomic ground state molecule in an arbitrary rovibrational level at large mutual separations is investigated with a general second-order perturbation theory, in the perspective of modeling the photoassociation between cold atoms and molecules. We find that the combination of quadrupole-quadrupole and van der Waals interactions compete with the rotational energy of the dimer, limiting the range of validity of the perturbative approach to distances larger than 100 a.u.. Numerical results are given for the long-range interaction between Cs and Cs_2, showing that the photoassociation is probably efficient whatever the Cs_2 rotational energy.

A 26.77 Thu 16:00 P2

Prospects for photoassociation of ultracold alkali-strontium compounds — Romain Guérout[2], Mireille Aymar[1], and •Olivier Dulieu[1] — [1]Laboratoire Aimé Cotton, CNRS/Université Paris-Sud, Orsay, France — [2]Laboratoire Kastler-Brossel, CNRS/Université Pierre et Marie Curie, Paris, France

In this work, we investigate the previously unknown electronic structure and properties of ionic and neutral diatomic molecules which could be formed from cold Strontium ions or atoms and ultracold alkali atoms A (A=Li, Na, K, Rb, Cs). The ionic (A-Sr^+) and neutral (A-Sr)species are modeled as effective two- and three-valence electron systems respectively, in the field of polarizable ionic cores Sr^+ and A^+ represented by effective core potentials. Potential curves, permanent and transition dipole moments are computed from a standard quantum chemistry approach with Full Configuration Interaction. Possible paths for charge exchange processes and for photoassociation are presented in the perspective of upcoming experiments.

A 26.78 Thu 16:00 P2

Ion - ion collisions in strongly coupled ultracold plasmas — •Georg Bannasch[1], Thomas Pohl[1], Jose Castro[2], Patrick McQuillen[2], and Thomas Killian[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden — [2]Physics & Astronomy Department, Rice University, Houston, USA

Collisions between charged plasma particles are often described by the famous Spitzer collision rate [1]. The Spitzer theory is based on the assumption that the Debye screening length is larger than the mean interparticle distance, i.e. that the plasma is weakly coupled. Laboratory-based ultracold plasmas, on the other hand, grant experimental access to the strong coupling regime, in which the Spitzer collision rate may diverge.

Here, we present a joint experimental theoretical study of ion - ion collisions in such an ultracold plasma. Velocity-selective optical pumping combined with fluorescence measurements permits to observe the dynamics of velocity relaxation on relevant timescales. In addition, we present exhaustive molecular dynamics simulations that yield good agreement with the experiment, and combined with a statistical description allow to characterize the collision rate at the onset of correlations and deep in the strongly coupled regime.

[1] Jr. L. Spitzer. Physics of Fully Ionized Gases. Wiley, New York, 1962

A 26.79 Thu 16:00 P2

Rydberg Atoms on an Atom Chip — •Atreju Tauschinsky, Vanessa Leung, H.B. van Linden van den Heuvell, and R.J.C. Spreeuw — Universiteit van Amsterdam, Amsterdam, The Netherlands

We present our new system for investigating Rydberg interactions on an atom chip. It is composed of a structured permanent magnetic film on an atom chip[1], allowing the creation of square and triangular arrays of hundreds of microtraps for ultracold atoms. The structure of the magnetic film has been designed for optimal trap geometries using a fast numerical algorithm[2]. The high trap frequencies (> 10kHz) and relatively small lattice constants of approximately 5μm allow the investigation of both inter- and intra-trap interactions, as well as further investigations of surface effects using Rydberg excited atoms[3]. The implementation of a high-NA imaging system should allow single-atom detection using absorption imaging. These characteristics make our system an excellent starting point for studies of atom-surface interactions, many-body physics and quantum information science involving interacting Rydberg atoms on chips.

[1]S. Whitlock *et al.* Two-dimensional array of microtraps with atomic shift register on a chip. New J. Phys. **11**, 023021 (2009)

[2]Roman Schmied *et al.* Optimized magnetic lattices for ultracold atomic ensembles. New J. Phys. **12**, 103029 (2010)

[3]Atreju Tauschinsky *et al.* Spatially resolved excitation of Rydberg atoms and surface effects on an atom chip. Phys. Rev. A **81**, 063411 (2010)

A 26.80 Thu 16:00 P2

Entanglement transport and conical intersections in flexible Rydberg aggregates — •Sebastian Wüster, Sebastian Möbius, Cenap Ates, Alexander Eisfeld, and Jan-Michael Rost — MPI-PKS Dresden

Transfer of electronic excitations on chains of atoms or molecules is important in many areas of physics, such as photosynthetic light-harvesting or assemblies of Rydberg atoms in optical lattices. The electromagnetic interactions responsible for excitation propagation also exert mechanical forces on the chain, inducing motion of the constituents. In such a flexible aggregate, the atomic motion is typically entangled with the state of the electronic excitation. We consider a linear and a circular arrangement of Rydberg atoms on which a single electronic excitation propagates via dipole-dipole transitions, forming a Frenkel exciton.

A 26.81 Thu 16:00 P2

Ion acoustic waves in strongly correlated ultracold neutral plasmas — •Cornelia Lechner, Christian Knapp, and Alexander Kendl — Institut für Ionenphysik und Angewandte Physik, Universität Innsbruck, Technikerstraße 25, A-6020 Innsbruck, Austria

Recent experiments on ultracold neutral plasmas (UNPs) report on the creation and observation of ion acoustic waves, which belong to the class of low-frequency, electrostatic plasma waves [1]. Surprisingly, despite significant deviations from standard plasma parameters, e.g. the strong coupling regime of the ions and the expansion into vacuum, the observed density oscillations seem to be well described by the standard dispersion relation of ion acoustic waves.

We study the influence of strong Coulomb-coupling on ion acoustic waves in UNPs. By taking into account ionic correlations, we obtain the modified dispersion relation. Deviations from the standard dispersive behavior are expected with an increasing degree of correlations. Ion acoustic waves are usually affected by Landau damping, unless the ion temperature satisfies $T_i \ll T_e$. Since the latter is true for UNPs, a different kind of damping behavior might be expected.

[1] J. Castro, P. McQuillen, and T. C. Killian, Phys. Rev. Lett. **105**, 065004 (2010)

A 27: Nano Plasmonic (with HL)

Time: Friday 10:30–13:00 Location: BAR 205

Invited Talk A 27.1 Fri 10:30 BAR 205

Plasmon Driven Higher Harmonics Generation — In-Yong Park, Seungchul Kim, Joon-Hee Choi, and •Seung-Woo Kim — Ultrafast optics for ultraprecision research group, KAIST, Daejeon, Republic of Korea

Plasmonic resonance enables field enhancement of a low-intensity fs pulse, permitting high harmonic generation without an additional amplifier. This new concept of generating ultrafast higher harmonic pulse was previously demonstrated using Au bow-tie antennas. The resulting intensity enhancement factor reached ~20 dB and successfully produced up to the 21st harmonic. Notwithstanding the high enhancement factor, the 2-dimensional configuration of the bow-tie nanostructure was found sensitive to thermal damages preventing practical usage. To cope with the problem, a 3-dimensional solid nanostructure is newly proposed and tested in this investigation. The newly designed nanostructure takes the shape of an ellipsoidal tapered waveguide fabricated in a cantilever micro-structure. The tapered waveguide functions as a plasmonic device that induces field enhancement by exploiting surface-plasmon polaritons being created as a femtosecond pulse propagates through. In comparison to bow-tie nano-antennas, the use of surface plasmon polaritons offers a much larger volume of enhanced laser field due to counter-propagating surface plasmon modes within the waveguide in response to the incident femtosecond pulse. The intensity of incident NIR pulses is enhanced by a factor of ~350, being strong enough to produce EUV harmonics up to the 43rd order directly from a modest input intensity of 1012 Wcm-2 in interaction with Xe gas.

Invited Talk A 27.2 Fri 11:00 BAR 205
Structure and Dynamics of Free Nanoparticles: From Charging to Time-Resolved Photoemission — •Eckart Rühl — Physikalische Chemie, Freie Universität Berlin, Takustr. 3, 14195 Berlin

Nanoscopic systems prepared from nanoparticles as unique building blocks have the advantage that their properties depend critically on the single nanoscopic units and their assembly on substrates. Single nanoparticles show often size and composition dependent optical, electronic, structural, and dynamical properties. This includes quantum size effects, which are efficiently modified by the internal structure of the nanoparticles and their surroundings. Recent progress in chemical syntheses of structured nanoparticles as well as properties of single nanoparticles is presented. This includes controlled preparation of dimers or small aggregates of nanoparticles. Single, free nanoparticles without any contact to other particles or substrates are either prepared in traps or focused nanoparticle beams. These approaches allow us to study the intrinsic size- and composition dependent properties of isolated nanoscopic matter and their photon-induced dynamics. Results from a variety of different experimental approaches making use of synchrotron radiation and ultra-short laser pulses are presented. These provide specific information on the electronic structure, plasmonic excitations, the location of the emitted electrons in nanoparticles, the dynamics of electron emission and cation formation, as well as the dynamics of collective electronic excitations in the femtosecond time domain.

Invited Talk A 27.3 Fri 11:30 BAR 205
Terahertz Nano Plasmonics — •Dai-Sik Kim — Center for Subwavelength Optics, Department of Physics and Astronomy, Seoul National University, Seoul, Korea

In this talk, we will focus on how terahertz electromagnetic waves, with wavelengths in the millimeter scale, can funnel through nano slits and nano slot antennas. The field enhancement is enormous, three orders of magnitudes, which can be used for nonlinear processes and ultrasensitive probing of underlying structures. Optics in extreme subwavelength regime resembles electro-statics involving capacitors, in contrast to the electromangetic waves in free space.

Invited Talk A 27.4 Fri 12:00 BAR 205
Coulomb complexes: Electron emission from clusters in strong FEL pulses — •Ulf Saalmann — MPI for the Physics of Complex Systems

The response of atomic clusters to short intense pulses at extreme-ultraviolet (XUV) and Xray wavelengths — as available from short-wavelength free-electron laser (FEL) sources like FLASH in Hamburg/Germany, the SCSS in Japan or LCLS in Stanford/California — is studied theoretically. Due to the high photon flux the clusters become multiply charged by massive electron emission. We device a model, which we call Coulomb complexes [1], in order to investigate the emission process. It turns out that the electron spectra strongly depend on the ionization rate. For low rates the electron release occurs sequentially and our model allows for an analytical description of the plateau-like electron spectra [1]. At high rates a dense nanoplasma is formed and ionization occurs through energy-exchanging collisions resulting in exponential electron spectra [2]. Both mechanisms can be understand in terms of our model containing only very few parameters available from experiments.

[1] Gnodtke, Saalmann, Rost, New J. Phys. in press (2011).
[2] Bostedt et al., New J. Phys. 12, 083004 (2010).

Invited Talk A 27.5 Fri 12:30 BAR 205
Appearance of Surface and Volume Plasmons in Fullerenes — •Sanja Korica[1], Axel Reinköster[1], Markus Braune[1], Jens Viefhaus[1], Daniel Rolles[1], G. Fronzoni[2], D. Toffoli[2], M. Stener[2], P. Decleva[2], O. Al-Dossary[3], Burkhard Langer[4], and Uwe Becker[1,3] — [1]Fritz-Haber-Institut der MPG, Berlin — [2]Universitá di Trieste, Italy — [3]King Saud University, Riyadh, Saudi-Arabia — [4]Freie Universität Berlin

Since the discovery of the C_{60} molecule in 1985 many studies have been performed to investigate its fundamental properties. These properties are mainly driven by its unique molecular structure like its spherical shell. One of the important characteristics of this molecule is the collective response of its valence electron cloud to electromagnetic radiation. This collective behavior gives rise to the occurrence of the giant dipole resonance a surface plasmon in the absorption spectrum centered around 20 eV, which has been analyzed theoretically by various authors. In addition, our photoionization cross-section measurements reveal a resonance near 40 eV, a volume plasmon analogous to observations made for C_{60} ions. Time-dependent density functional calculations confirm the collective nature of this feature as corresponding plasmon excitation. A third excitation of this kind is predicted but not experimentally confirmed. Concerning photoelectron emission, plasmonic excitations are characterized by a particular intensity behavior near threshold. They follow the threshold behavior law predicted for the first time by Thomas Derrah. Our measurements of the C_{60} plasmon excitations above the C 1s ionization threshold confirm this law very well and are in unexpectedly good agreement with the corresponding behavior of K-shell satellite excitations in atoms such as neon.

A 28: Attosecond physics II

Time: Wednesday 10:30–12:45 Location: BAR 205

Invited Talk A 28.1 Wed 10:30 BAR 205
Quantum Interference Control of Free and Bound Electrons in Atoms and Molecules — •Thomas Pfeifer — Max-Planck Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Electrons are the fundamental building blocks of molecular and condensed-phase bonds and the motion of electrons (migration, localization, ionization, etc.) governs the course of chemical reactions and defines molecular potential-energy landscapes. In the valence shell of atoms and molecules, electron dynamics typically proceeds on few-femtosecond and faster time scales, such that extremely short pulses and controlled light electric fields are needed to measure and to control these scientifically relevant quantum-electronic processes.

In this talk, we shall discuss experiments and the physical description of electronic quantum control. It will be shown that by using very short light pulses with a stabilized carrier-envelope phase (CEP) – and thus a fully controlled temporal electric field evolution – it is possible to steer the process of ionization and electron localization in atoms and molecules.

Most importantly, we can identify the mechanisms of this type of control as fundamental scenarios of quantum control among energetically degenerate states. As theoretically established by Brumer and Shapiro a long time ago, quantum interference among different light-induced transition pathways in atoms and molecules is at the heart of electronic control experiments. The intuitive physical pictures arising from this traditional understanding of electronic control in combination with the possibilities opened up by modern CEP-stabilized laser light electric fields and attosecond pulses paves the way towards more comprehensive applications of electronic control in more complex systems.

A 28.2 Wed 11:00 BAR 205
Decoherence in Attosecond Photoionization — •Stefan Pabst[1,2], Loren Greenman[3], Phay J. Ho[4], David A. Mazziotti[4],

and Robin Santra[1,2] — [1]Center for Free-Electron Laser Science, DESY, Notkestrasse 85, 22607 Hamburg, Germany — [2]Department of Physics,University of Hamburg, Jungiusstrasse 9, 20355 Hamburg, Germany — [3]Department of Chemistry and The James Franck Institute, The University of Chicago, Chicago, Illinois 60637, USA — [4]Argonne National Laboratory, Argonne, Illinois 60439, USA

The creation of superpositions of hole states via single-photon ionization using attosecond extreme-ultraviolet pulses is studied with the time-dependent configuration interaction singles (TDCIS) method. Specifically, the degree of coherence between hole states in atomic xenon is investigated. We find that interchannel coupling not only affects the hole populations, it also enhances the entanglement between the photoelectron and the remaining ion, thereby reducing the coherence within the ion. As a consequence, even if the spectral bandwidth of the ionizing pulse exceeds the energy splittings among the hole states involved, perfectly coherent hole wave packets cannot be formed. For sufficiently large spectral bandwidth, the coherence can only be increased by increasing the mean photon energy.

A 28.3 Wed 11:15 BAR 205

Time-resolved phase matching and macroscopic gating in few-cycle high-harmonic generation: Simulation and experimental results — •Michael Schönwald, Christian Ott, Philipp Raith, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Heidelberg, Deutschland

High-harmonic generation (HHG) is a key technology for the direct exploration of atomic and molecular electron dynamics. This process is based on a macroscopically coherent response of a medium, i.e. the radiation produced by multiple atoms has to be phase matched. A time-domain simulation of phase matching will be presented, showing how phase matching can act as a temporal gate and thus allow HHG only during the leading edge of the driving laser pulse. The behaviour of the leading-edge gating mechanism will be analysed for different experimental conditions, such as peak intensity of the driving laser pulse, density of the gaseous generation medium and the distance between focus and generation medium. In our experiments, the leading-edge gate is observed by carrier-envelope phase (CEP) dependent measurements of HHG, including analysis of the half-cycle cut-off (HCO) emission. Experiments are carried out for various pressures and compared to the simulation. The HCO photon energy allows to extract the field strength of an individual half cycle of the driving laser pulse. In addition, the pressure-dependent total harmonic yield measured in the experiment is compared to the simulation for the leading-edge regime and yields a qualitative agreement, further confirming our understanding of the process that allows to generate isolated attosecond pulses.

A 28.4 Wed 11:30 BAR 205

Spectral reshaping of pulses propagating within a filament — •Emilia Schulz[1], Daniel S. Steingrube[1], Thomas Binhammer[2], Mette B. Gaarde[3], Arnaud Couairon[4], Uwe Morgner[1], and Milutin Kovacev[1] — [1]Leibniz Universität Hannover, Welfengarten 1 D-30167 Hannover, Germany; QUEST, Centre for Quantum Engineering and Space-Time Research, Hannover, Germany — [2]VENTEON Laser Technologies GmbH, D-30827 Garbsen, Germany — [3]Department of Physics and Astronomy, Louisiana State University, Baton Rouge, Louisiana 70803-4001, USA; PULSE Institute, SLAC National Accelerator Laboratory, Menlo Park, California 94025, USA — [4]Centre de Physique Theorique, Ecole Polytechnique, CNRS, F-91128, Palaiseau, France

Filamentation of ultra-short laser pulses has become a versatile tool for ultra-fast applications as e.g. few-cycle-pulse generation. The complex spatio-temporal dynamics taking place during the filamentation process are so far only predicted from numerical simulations, and only a few efforts have been done in the experimental investigation of the evolution of propagating pulses within a filament. We present a cell design which is capable to realize a pressure gradient from 1000 mbar argon to a vacuum pressure of below 10^{-4} mbar over a distance of about 1 cm. This enables the investigation of filaments along their propagation direction. Self focusing and spectral broadening of the pulse during the filamentation process can now be investigated in detail. We present experimental results showing the influence of pressure and chirp on the spectral broadening. Numerical calculations show excellent agreement.

A 28.5 Wed 11:45 BAR 205

Spectrally resolved Maker Fringes in High-Order Harmonic Generation — •Christoph M. Heyl[1], Jens Güdde[2], Ulrich Höfer[2], and Anne L'Huillier[1] — [1]Department of Physics, Lund University, Lund, Sweden — [2]Fachbereich Physik und Zentrum für Materialwissenschaften, Philipps-Universität, Marburg, Germany

We present theoretical and experimental studies of macroscopic interference effects in high-order harmonic generation (HHG) using 6 μJ, 45 fs laser pulses at 100 kHz repetition rate.

Every harmonic spectrum contains a fingerprint of both, microscopic and macroscopic effects. So far, however, mostly single atom effects have been emphasized. In a series of recent studies interference structures in HHG spectra have been interpreted as due to interferences between long and short electron trajectories which has been called quantum path interference (QPI). Here, we focus on the macroscopic effects and investigate how phase matching affects the harmonic spectrum. We show how the appearance of spectral fringes can be explained in terms of Maker fringes, due to the time dependent coherence length of the long trajectory. We explain further, how these spectral Maker fringes contain direct information about the time dependent phase matching conditions as well as about the intensity dependent phase of the microscopic dipole moment.

A 28.6 Wed 12:00 BAR 205

High-order harmonic generation by intensity spikes within filamention — •Daniel S. Steingrube[1], Emilia Schulz[1], Thomas Binhammer[2], Mette B. Gaarde[3], Arnaud Couairon[4], Uwe Morgner[1], and Milutin Kovacev[1] — [1]Leibniz Universität Hannover, Institut für Quantenoptik, Welfengarten 1, D-30167 Hannover, Germany; QUEST, Centre for Quantum Engineering and Space-Time Research, Hannover, Germany — [2]VENTEON Laser Technologies GmbH, D-30827 Garbsen, Germany — [3]Department of Physics and Astronomy, Louisiana State University, Baton Rouge, Louisiana 70803-4001, USA; PULSE Institute, SLAC National Accelerator Laboratory, Menlo Park, California 94025, USA — [4]Centre de Physique Theorique, Ecole Polytechnique, CNRS, F-91128, Palaiseau, France

Few-cycle pulse generation using filamentation for pulse compression has been shown in a number of recent studies. These short and intense pulses can be applied for high-order harmonic generation (HHG) which is a prerequisite to the production of attosecond pulses.

We realized an experimental setup to combine both steps of pulse compression and HHG in a semi-infinite gas cell at atmospheric pressure where the critical power for filamentation is reached. The generation of high-order harmonics directly in the filament shows the occurrence of intensity spikes above the clamping intensity of filamentation. Our results confirm recent theoretical predictions and show a continuous harmonic spectrum in the XUV-spectral range promising for single attosecond pulse generation directly from a filament.

A 28.7 Wed 12:15 BAR 205

Attosecond Twin-Pulse Control by Generalized Kinetic Heterodyne Mixing — •Philipp Raith, Christian Ott, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

Attosecond double pulses with defined spectral properties (e.g. spectral-phase difference between the pulses) are a useful tool for spectral interferometry measurements of attosecond quantum dynamics in atoms and molecules. For this purpose, we study the generation and manipulation of attosecond double-pulse (called twin pulse at identical intensities of the two pulses) production in high-order harmonic generation by a combination of two-color laser fields and carrier-envelope-phase (CEP) control methods. It is shown that both relative amplitude and phase of the double pulses can be independently set by making use of multidimensional parameter control methods. Two technical implementation routes are discussed: kinetic heterodyne mixing of a strong laser field and its second harmonic and split-spectrum phase-step control using a single spectrally coherent broad-band laser field. This multidimensional control scheme including the CEP can be considered a general approach for controlling electron dynamics for applications ranging from electron localization in molecules to attosecond pulse shaping.

A 28.8 Wed 12:30 BAR 205

Attosecond neutron scatterig from H2 and D2 — •C. Aris Dreismann[1], Evan Gray[2], and Tom Blach[2] — [1]Institute of Chemistry, TU Berlin, Germany — [2]Griffith University, School of Biomolecular and Physical Sciences, Brisbane, Australia

Quantum entanglement (QE) has emerged as the most emblematic feature of quantum mechanics. Nuclei and electrons in condensed matter and/or molecules are usually entangled, due to the prevailing interactions. However the "environment" of a microscopic system (e.g. a proton in a H2 molecule) may cause an ultrafast decoherence thus making atomic and/or nuclear QE effects not directly accessible to experiments. Applying neutron Compton scattering (NCS) in the energy transfer range of ca. 1-100 eV, the relevant proton-neutron scattering time lies in the sub-femtosecond time range. Results of current NCS experiments from H2 and D2 in the gas phase at T = 40 K are reported, showing that the measured Compton profiles (in the attosecond scattering range) reveal new features of quantum dynamics which contradict conventional theoretical expectations. The experimental NCS setup of ISIS, Rutherford Appleton Laboratory is shortly introduced. The theoretical frame of "attosecond scattering from open quantum systems" [1] is discussed, in connection with the new experimental findings.

[1] C. A. Chatzidimitriou-Dreismann and M. Krzystyniak, Laser Physics **20**, 990 (2010).

A 29: Ultracold Atoms: Trapping and Cooling 2 (with Q)

Time: Friday 10:30–13:00 Location: HSZ 02

A 29.1 Fri 10:30 HSZ 02

CPT and EIT - Dark state resonances in interacting systems — •Hanna Schempp[1], Georg Günter[1], Christoph S. Hofmann[1], Thomas Amthor[1], Matthias Weidemüller[1], Jonathan D. Pritchard[2], Daniel Maxwell[2], Alex Gauguet[2], Kevin J. Weatherill[2], Matthew P.A. Jones[2], Charles S. Adams[2], Sevilay Sevinçli[3], Cenap Ates[3], and Thomas Pohl[3] — [1]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg — [2]Department of Physics, Durham University, Rochester Building, South Road, Durham DH1 3LE, United Kingdom — [3]Max-Planck-Institut für Physik Komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden

Coherent Population Trapping (CPT) and the related phenomenon of Electromagnetically Induced Transparency (EIT) are paradigms for quantum interference effects. EIT involving a Rydberg state has recently been studied experimentally [1] and has also attracted much interest in the context of quantum information processing [2]. In this work we compare experiments on CPT [3] and EIT [4] in Rydberg gases with controlled interparticle interactions. We present many-body calculations which take the resulting interparticle correlations into account.

[1] A. K. Mohapatra et al., PRL 98 113003 (2007)
[2] M. Müller et al., PRL 102 170502 (2009)
[3] H. Schempp et al., PRL 104 173602 (2010)
[4] J.D. Pritchard et al., PRL 105 193603 (2010)

A 29.2 Fri 10:45 HSZ 02

Enhanced Optical Nonlinearities with Cold Rydberg Gases — •Sevilay Sevinçli[1], Cenap Ates[2], and Thomas Pohl[1] — [1]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Strasse 38, 01187 Dresden, Germany — [2]School of Physics and Astronomy, University of Nottingham, Nottingham, NG7 2RD, United Kingdom

Owing to the high sensitivity of Rydberg atoms to external fields and to interactions among themselves, ultracold Rydberg gases provide an ideal system for nonlinear optics. Here, we present a quantum and a classical many-body approach to describe interaction effects on the propagation of classical light pulse in an Rydberg-EIT medium. The nonlinear susceptibility shows perfect match between the two methods and is shown to exhibit a universal scaling behavior.

We further propose a microvawe dressing scheme, that allows to modify the interactions between Rydberg atoms, and thereby control the optical properties of the gas. In particular, this allows to greatly enhance genuine three-body interactions, giving rise to large fifth-order nonlinearities. Finally, we present an analytical derivation of the optical susceptibility, providing an intuitive picture for these effects.

A 29.3 Fri 11:00 HSZ 02

Homodyne Detection of Matter Wave — •Stefan Rist[1] and Giovanna Morigi[2,3] — [1]NEST, Scuola Normale Superiore & Istituto di Nanoscienze - CNR, Piazza dei Cavalieri 7, I-56126 Pisa, Italy — [2]Departament de F\'isica, Universitat Aut\'onoma de Barcelona, E-08193 Bellaterra, Spain — [3]Theoretische Physik, Universit\"at des Saarlandes, D-66041 Saarbr\"ucken, Germany

We present a scheme which allows one for measuring the mean value of the atomic field operator of an ultracold bosonic gas. The scheme we consider is an extension of the experimental setups in [1,2] where atoms were outcoupled of two Bose-Einstein condensates by means of Bragg-scattering. Our scheme is the matter-wave analogon of homodyne detection in optics, where a quantum field is superposed at a beam splitter to a local oscillator. In our case the local oscillator is a Bose-Einstein condensate, from which atoms are outcoupled by means of two Raman lasers, and superimposed with the atoms outcoupled from the atomic system to determine.

The measurement is performed in the light scattered into one of of the Raman beams which is shown to be proportional to the mean value of the field operator of the atomic system. We provide two examples, such as the measurement of the temperature of a Bose-Einstein condensate and of the superfluid fraction in an optical lattice.

[1] M. Saba et al. Science 307, 1945 (2005).
[2] Y.~Shin et al. Phys. Rev. Lett. 95, 170402 (2005).

A 29.4 Fri 11:15 HSZ 02

A Double-Species 2D+MOT for Potassium and Rubidium — •Lucia Duca[1], Tracy Li[1], Martin Boll[1], Jens Philipp Ronzheimer[1], Ulrich Schneider[1], and Immanuel Bloch[1,2] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität, 80799 München — [2]Max-Planck-Institut für Quantenoptik, 85748 Garching

In recent years there has been a growing interest in the realization of low entropy phases of the Fermi-Hubbard model using ultracold fermions in optical lattices. One of the requirements for achieving e.g. anti-ferromagnetic order is to reduce the initial temperature below $T/T_F<0.065$ [1]. This requires a careful elimination of all heating sources and an optimization of all cooling steps.

Within a new experimental setup that is currently under construction, we use a double-species 2D+MOT [2] for ^{40}K and ^{87}Rb as an atomic source of slow atoms. Compared to the use of dispensers, this pre-cooling stage allows us to operate the 3D MOT at pressures below 10^{-10} mbar while simultaneously speeding up the experimental cycle and increasing the number of trapped K atoms that will be available for evaporative cooling. We present our 2D+MOT setup and our first experimental results.

[1] Fuchs et.al., arXiv: 1009.2759v1
[2] Dieckmann et.al., PRA 58, 3891 (1998).

A 29.5 Fri 11:30 HSZ 02

Microwave guiding of electrons in a planar quadrupole guide — •Johannes Hoffrogge, Roman Fröhlich, Jakob Hammer, and Peter Hommelhoff — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching bei München

We present the transverse confinement and guiding of electrons in a linear AC quadrupole guide operated at microwave frequencies. The guiding potential is generated by the electrode pattern of a microfabricated planar Paul trap. This facilitates the combination with microwave transmission lines patterned on the same substrate to achieve the high driving frequencies necessary for stable electron confinement. In a proof-of principle experiment [1] we demonstrate successfull guiding in an electrically short device by conducting laterally confined electrons along a curved trajectory. The guide is operated at 1 GHz driving frequency and generates a two dimensional potential with 150 MHz trapping frequency 500 μm away from the surface. We also characterize the guiding behaviour of this device in terms of trap depth and stability and compare it to numerical particle tracking simulations. The precise control over the electrons and the possibility to easily scale the trapping potential to more complicated structures opens a wide range of applications. With a single atom tip as electron source, it might become feasible to directly inject electrons into the transverse ground state of motion of the guide. When combined with beam splitting devices this will enable experiments like guided electron interferometry or the controlled interaction of confined electrons.

[1] J. Hoffrogge, R. Frohlich and P. Hommelhoff - submitted (2010)

A 29.6 Fri 11:45 HSZ 02

Ultracold atoms in disordered quantum potential — •Hessam Habibian[1,2], Wolfgang Niedenzu[3], Helmut Ritsch[3], and Giovanna Morigi[1,2] — [1]Grup d'Optica, Departament de Física, Universitat Autònoma de Barcelona, E-08193 Bellaterra, Barcelona, Spain — [2]Theoretische Physik, Universität des Saarlandes, D-66041 Saarbrücken, Germany — [3]Institut für Theoretische Physik, Universität Innsbruck, A-6020 Innsbruck, Austria

We study the self-organized atomic patterns which emerge by mechanical effect of light in an optical resonator when the atoms are driven by a laser. The laser wave vector is at a tilted angle from the axis of the cavity such that the light scattered by each atom has a (pseudo-)random phase. Depending on the intensity of the laser and the angle with the cavity axis, the atomic crystal may exhibit defects. We study the quantum ground state of the system in this configuration.

A 29.7 Fri 12:00 HSZ 02

Laserkühlung von dichten atomaren Alkali-Edelgas-Mischungen durch kollisionsinduzierte Fluoreszenzredistribution — •Anne Sass, Ulrich Vogl, Simon Hasselmann und Martin Weitz — Institut für Angewandte Physik der Universität Bonn, Wegelerstraße 8, D-53115 Bonn

Der Grundgedanke, Materie mit Licht zu kühlen, wurde erstmals 1929 von Peter Pringsheim vorgestellt. Seither haben sich Doppler-Kühlung dünner atomarer Gase und zuletzt Anti-Stokes-Kühlung von Festkörpern als sehr erfolgreiche Anwendungen dieses Konzeptes herausgestellt. Das hier vorgestellte Verfahren der stoßinduzierten Redistributionskühlung stellt einen neuartigen Laserkühlmechanismus basierend auf atomaren Zwei-Niveau-Systemen dar. Wir berichten über Experimente zur Kühlung von Alkali-Edelgas-Mischungen in einer Hochdrucksichtzelle bei einigen hundert bar Druck. Kollisionen im dichten Gas ermöglichen die Absorption eines rot verstimmt eingestrahlten Laserstrahls, der spontane Zerfall erfolgt nah an der ungestörten Resonanz. Die so pro Kühlzyklus aus dem atomaren Ensemble extrahierte Energie liegt in der Größenordnung der thermischen Energie kT; die Dichte des gekühlten Gases ist um mehr als zehn Größenordnungen höher als die typischen Werte in Experimenten zur Doppler-Kühlung. Aktuell erreichen wir in unseren Experimenten relative Temperaturänderungen um 120 K und 527 K für unterschiedliche Alkaliatomspezies. Zukünftig gilt es, das Kühlprinzip auch auf molekulare Gase anzuwenden und die technische Anwendbarkeit des Verfahrens, etwa für Kryokühler, zu überprüfen.

A 29.8 Fri 12:15 HSZ 02

A hexapole-compensated magneto-optical trap on a mesoscopic atom chip — •Stefan Jöllenbeck[1], Jan Mahnke[1], Richard Randoll[1], Manuela Hanke[1], Ilka Geisel[1], Wolfgang Ertmer[1], Jan Arlt[2], and Carsten Klempt[1] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Department of Physics and Astronomy, Aarhus University

We realized a magneto-optical trap (MOT) on a mesoscopic chip structure which will be used as a starting point for experiments to trap and transport atoms in a magnetic conveyor belt.

Our MOT setup consists of nine millimeter-scale wires which generate a quadrupole field with minimized distortions. The wires are placed outside of our vacuum system above a steel foil which forms one wall of our vacuum chamber. A gold coating on the vacuum side of this foil allows for the standard mirror MOT configuration. Together with a pre-cooled beam from a $2D^+$-MOT, we achieve an initial loading rate of 8.4×10^{10} atoms/s and a final number of 8.7×10^9 captured atoms within 300 ms.

Since the MOT can be operated by only local magnetic fields, the wire structure will support a serialized production of Bose-Einstein condensates in the magnetic conveyor belt.

A 29.9 Fri 12:30 HSZ 02

Reconstructing the Wigner function of an atomic ensemble — •Roman Schmied and Philipp Treutlein — Departement Physik, Universität Basel, Schweiz

At the core of quantum information technology lies the deterministic and robust generation of entanglement. The accurate measurement of this entanglement is central for advancing the techniques for entanglement generation. For this we have developed a novel method which allows us to reconstruct the Wigner function of the total pseudospin of a large ensemble of ultracold atoms from tomographic data. We illustrate the method with experimental data from a spin-squeezed cloud of ^{87}Rb atoms.

A 29.10 Fri 12:45 HSZ 02

Optimized magnetic lattices for ultracold atomic ensembles — •Roman Schmied[1], Dietrich Leibfried[2], Robert Spreeuw[3], and Shannon Whitlock[4] — [1]Departement Physik, Universität Basel, Schweiz — [2]National Institute of Standards and Technology, Boulder, CO, USA — [3]Van der Waals–Zeeman Instituut, Universiteit van Amsterdam, The Netherlands — [4]Physikalisches Institut, Universität Heidelberg

Atom chips provide a versatile and reliable laboratory for quantum-mechanical experiments with ultracold atoms. The next generation of atom chips calls for a dramatic increase in the complexity of the spatially structured electromagnetic fields required for trapping and manipulating these atoms. We introduce a general method* for designing tailored lattices of magnetic microtraps for ultracold atoms on the basis of patterned permanently magnetized films. A fast numerical algorithm is used to automatically generate patterns that provide optimal atom confinement while respecting the desired lattice topology and trap parameters. This will allow atom-chip based quantum technology to be extended to arrays of microtraps with state-dependent potentials, opening the way to constructing quantum processors and quantum simulators through interacting ultracold atoms.

* R. Schmied *et al.*, New J. Phys. **12**, 103029 (2010)