Atomic Physics Division (A)

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Overview of Invited Talks and Sessions

(lecture rooms A 320, B 302, E 415, F 107, F 142, F 303; poster Lichthof)

Invited Talks

A 1.1	Mo	14:00–14:30	F 303	**Quantum Dynamics Visualized by Reaction Microscopes: From intense virtual towards real attosecond photon fields** — •Joachim Ullrich, Robert Moshammer
A 1.2	Mo	14:30–15:00	F 303	**Strong Field Dynamics Studied with Ion and Electron Momentum Imaging** — •Lewis Cocke, Dipanwita Ray, Sankar De, Wei Cao, Guillaume Laurent, ChiiDong Lin, AT Le, Zhangjin Chen, Feng He, Uwe Thumm
A 1.3	Mo	15:00–15:30	F 303	**Breaking the longest bond – Photoionization of the Helium Dimer** — •R. Dörner, T. Havermeier, H. Sann, T. Jahnke, M. Schöffler, J. Titze, N. Neumann, K. Kreidi, R. Wallauer, S. Voss, L. Ph. H. Schmidt, H. Schmidt-Böcking, R. Grisenti, W. Schöllkopf
A 1.4	Mo	15:30–16:00	F 303	**Complete (e,2e) experiments with COLTRIMS** — •Alexander Dorn
A 4.1	Mo	16:30–17:00	F 303	**A hitherto unrecognized source of low-energy electrons in water** — •Melanie Mucke, Markus Braune, Silko Barth, Marko Förstel, Toralf Lischke, Volker Ulrich, Tiberiu Arion, Uwe Becker, Alex M. Bradshaw, Uwe Hergenhahn
A 4.6	Mo	18:00–18:30	F 303	**Two-Center Interference in Valence Photoionization of N_2 and O_2** — •Markus Braune, Markus Ilchen, Sanja Korica, Andre Meissner, Lokesh Tribedi, Sascha Deinert, Leif Glaser, Frank Scholz, Peter Walter, Jens Viefhaus, Uwe Becker
A 6.1	Tu	14:00–14:30	F 303	**Probing weakly bound molecules with nonresonant light** — •Mikhail Lemeshko, Bretislav Friedrich
A 10.1	We	10:30–11:00	F 107	**The promises and challenges of precision spectroscopy of cold molecules** — •Steven Hoekstra
A 12.1	We	14:00–14:30	F 303	**Sequential two-photon double ionization of atoms in intense FEL radiation** — •Stephan Fritzsche, Alexei N. Grum-Grzhimailo, Elena V. Gryzlova, Nikolay M. Kabachnik
A 12.2	We	14:30–15:00	F 303	**Few-body physics with ultracold atoms** — •Selim Jochim, Thomas Lompe, Martin Ries, Friedhelm Serwane, Philipp Simon, Andre Wenz, Gerhard Zürn
A 13.1	We	14:00–14:30	F 107	**Testing strong-field CED and QED with intense laser fields** — •Antonino Di Piazza, Karen Z. Hatsagortsyan, Ben King, Christoph H. Keitel
A 14.1	We	16:30–17:00	F 303	**Stochastic Resonance Effects in open Bose-Einstein condensates** — •Dirk Witthaut, Friederike Trimborn, Sandro Wimberger
A 14.2	We	17:00–17:30	F 303	**CRASY: Correlated Rotational Alignment Spectroscopy** — •Thomas Schultz
A 19.1	Th	10:30–11:00	B 302	**Bound by reflection: Binding mechanisms of ultralong range Rydberg molecules** — •Weibin Li
A 20.1	Th	14:00–14:30	F 303	**The hydrated electron studied by fs-photoelectron spectroscopy** — •Andrea Lübcke, Franziska Buchner, Nadja Heine, Thomas Schultz, Ingolf Volkmar Hertel
A 20.2	Th	14:30–15:00	F 303	**Surface Quantum Optics: from Casimir-Polder forces to optical near-fields** — •Sebastian Slama
A 21.1	Th	14:00–14:30	F 107	**Acceleration of neutral atoms in strong short pulse laser fields** — •Ulli Eichmann

A 24.1	Fr	10:30–11:00	F 303	**Interacting Bosonic and Fermionic Atoms in 3D Optical Lattice Potentials** — •Sebastian Will, Thorsten Best, Simon Braun, Philipp Ronzheimer, Ulrich Schneider, Michael Schreiber, Kin Chung Fong, Lucia Hackermüller, Immanuel Bloch
A 24.2	Fr	11:00–11:30	F 303	**Dressing of Ground State Atoms by Rydberg States in a Ioffe-Pritchard Trap** — •Michael Mayle, Igor Lesanovsky, Peter Schmelcher
A 26.1	Fr	10:30–11:00	B 302	**Electron-initiated Chemistry** — Slim Chourou, Valery Ngassam, Asa Larson, •Ann Orel
A 26.2	Fr	11:00–11:30	B 302	**Astrophysically motivated electron collisions studies on M-shell iron ions** — •Michael Lestinsky, Oldřich Novotný, Michael Hahn, Dietrich Bernhardt, Stefan Schippers, Alfred Müller, Claude Krantz, Manfred Grieser, Roland Repnow, Andreas Wolf, Nigel Badnell, Daniel Wolf Savin

Invited talks of the joint symposium SYFC

See SYFC for the full program of the Symposium.

SYFC 1.1	Mo	14:00–14:30	A 001	**Fundamental constants, gravitation and cosmology** — •Jean-Philippe Uzan
SYFC 1.2	Mo	14:30–15:00	A 001	**Molecular hydrogen in the lab and in the early universe; search for varying mu** — •Wim Ubachs
SYFC 1.3	Mo	15:00–15:30	A 001	**Stability of the proton-to-electron mass ratio tested with molecular spectroscopy using an optical link to frequency reference** — •Anne Amy-Klein, Alexander Shelkovnikov, Robert J. Butcher, Olivier Lopez, Christophe Daussy, Haifeng Jiang, Fabien Kéfélian, Giorgio Santarelli, Christian Chardonnet
SYFC 1.4	Mo	15:30–16:00	A 001	**Optical clocks with trapped ions and the search for variations of fundamental constants** — •Ekkehard Peik
SYFC 2.1	Mo	16:30–17:00	A 001	**Gravitational and cosmological probes of varying fundamental parameters** — •Thomas Dent
SYFC 2.2	Mo	17:00–17:30	A 001	**The astrophysical search for varying fundamental constants** — •Nils Prause

Invited talks of the joint symposium SYDP

See SYDP for the full program of the Symposium.

SYDP 1.1	Mo	16:30–17:00	F 107	**Experimental all-optical one-way quantum computing** — •Robert Prevedel
SYDP 1.2	Mo	17:00–17:30	F 107	**Benchmarks and statistics of entanglement dynamics** — •Markus Tiersch
SYDP 1.3	Mo	17:30–18:00	F 107	**Squeezed Light For Gravitational Wave Astronomy** — •Henning Vahlbruch
SYDP 1.4	Mo	18:00–18:30	F 107	**High-precision mass measurements with Penning traps** — •Sebastian George

Invited talks of the joint symposium SYDC

See SYDC for the full program of the Symposium.

SYDC 1.1	Tu	14:00–14:30	E 415	**Environment-induced Decoherence of Quantum States: An Introduction** — •Heinz-Peter Breuer
SYDC 1.2	Tu	14:30–15:00	E 415	**Fighting Decoherence: Quantum Information Science with Trapped Ca^+ Ions** — T. Monz, K. Kim, A. Villar, P. Schindler, M. Chwalla, M. Riebe, C. F. Roos, H. Häffner, W. Hänsel, M. Hennrich, •R. Blatt
SYDC 1.3	Tu	15:00–15:30	E 415	**Decoherence phenomena in molecular systems: Localization of matter waves & stabilization of chiral configuration states** — •Klaus Hornberger
SYDC 1.4	Tu	15:30–16:00	E 415	**Decoherence of free electron waves and visualization of the transition from quantum- to classical-behaviour** — •Franz Hasselbach

SYDC 2.1	Tu	16:30–17:00	E 415	**Coherence and the loss of it in molecular photoionization** — •Uwe Hergenhahn
SYDC 2.2	Tu	17:00–17:30	E 415	**Decoherence in fermionic interferometers** — •Florian Marquardt
SYDC 2.3	Tu	17:30–18:00	E 415	**Quantum diffusion in gravitational waves backgrounds** — •Serge Reynaud, Brahim Lamine, Rémy Hervé, Astrid Lambrecht
SYDC 2.4	Tu	18:00–18:30	E 415	**Quantum coherence and decoherence in biological systems** — •Martin Plenio

Invited talks of the joint symposium SYLA

See SYLA for the full program of the Symposium.

SYLA 1.1	We	14:00–14:30	E 415	**How the laser happend** — •Herbert Welling
SYLA 1.2	We	14:30–15:00	E 415	**The origin of the quantum theory of lasing** — •Fritz Haake
SYLA 1.3	We	15:00–15:30	E 415	**Lasers for precision measurements** — •Thomas Udem
SYLA 1.4	We	15:30–16:00	E 415	**Short, Ultra Short, Atto Short** — •Dietrich von der Linde
SYLA 2.1	We	16:30–17:00	E 415	**Our Daily Life with Semiconductor Lasers** — •Dieter Bimberg
SYLA 2.2	We	17:00–17:30	E 415	**Power to the Industry - the story of Laser upscaling** — •Reinhart Poprawe
SYLA 2.3	We	17:30–18:00	E 415	**The Outstanding Qualities of Fiber Lasers and Thin Disk Lasers** — •Adolf Giesen
SYLA 2.4	We	18:00–18:30	E 415	**Solid State Lasers:meeting the challenges of the 21st Century** — •Robert L. Byer

Invited talks of the joint symposium SYSA

See SYSA for the full program of the Symposium.

SYSA 1.1	Th	10:30–11:00	A 320	**Cavity EIT with single atoms** — •Stephan Ritter, Martin Mücke, Eden Figueroa, Jörg Bochmann, Carolin Hahn, Celso J. Villas-Boas, Gerhard Rempe
SYSA 1.2	Th	11:00–11:30	A 320	**Optical detection of single trapped atoms with less than one spontaneous emission** — Jürgen Volz, Roger Gehr, Guilhem Dubois, Jérôme Estève, •Jakob Reichel
SYSA 1.3	Th	11:30–12:00	A 320	**Substantial interaction between a singe atom and a focused light beam** — •Gleb Maslennikov, Syed Abdullah Aljunid, Brenda Chng, Florian Huber, Meng Khoon Tey, Timothy Liew, Valerio Scarani, Christian Kurtsiefer
SYSA 1.4	Th	12:00–12:30	A 320	**Exploring Quantum Physics with Single Neutral Atoms** — •Artur Widera
SYSA 2.1	Th	14:00–14:30	A 320	**Detecting single ultra cold atoms** — •Jörg Schmiedmayer
SYSA 2.2	Th	14:30–15:00	A 320	**Entanglement of two individual neutral atoms using Rydberg blockade** — •Tatjana Wilk, Alpha Gaëtan, Charles Evellin, Janik Wolters, Yevhen Miroshnychenko, Philippe Grangier, Antoine Browaeys

Invited talks of the joint symposium SYDI

See SYDI for the full program of the Symposium.

SYDI 1.1	Fr	10:30–11:00	E 415	**Flash diffraction imaging with X-ray lasers** — •Janos Hajdu
SYDI 1.2	Fr	11:00–11:30	E 415	**The hitchhikers guide to cryo-electron tomography - A voyage to the inner space of cells** — •Juergen Plitzko
SYDI 1.3	Fr	11:30–12:00	E 415	**Far-Field Optical Nanoscopy by Optical Switching** — •Andreas Schönle, Stefan Hell
SYDI 1.4	Fr	12:00–12:30	E 415	**Coherent Diffractive Imaging at LCLS** — •Henry Chapman
SYDI 2.1	Fr	14:00–14:30	E 415	**High Harmonic Generation from Molecules: Prospects for ultra-fast imaging of molecular structure and dynamics** — •Jonathan Marangos
SYDI 2.2	Fr	14:30–15:00	E 415	**Time-resolved diffraction from selectively aligned molecules** — •Ernst Fill, Martin Centurion, Peter Reckenthäler, Werner Fuss, Ferenc Krausz

SYDI 2.3	Fr	15:00–15:30	E 415	**Imaging Molecules from Within: Ultra-fast Structure Determination of Molecules via Photoelectron Holography with Free Electron Lasers.** — •Joachim Ullrich, Faton Krasniqi, Bennaeur Najjari, Alexander Voitkiv, Sascha Epp, Daniel Rolles, Artem Rudenko, Lothar Strüder
SYDI 2.4	Fr	15:30–16:00	E 415	**Ultrafast processes and imaging of clusters** — •Thomas Möller

Invited talks of the joint symposium SYPS

See SYPS for the full program of the Symposium.

SYPS 1.1	Fr	11:00–11:30	A 001	**Status of QED tests in heavy highly charged ions** — •Paul Indelicato
SYPS 1.2	Fr	11:30–12:00	A 001	**Penning trap mass spectrometry with highly charged ions** — •Szilard Nagy
SYPS 1.3	Fr	12:00–12:30	A 001	**Diagnostic of Hot Dense Plasmas by Advanced XUV and X-ray Spectroscopy** — •Ingo Uschmann
SYPS 1.4	Fr	12:30–13:00	A 001	**Measurements of masses and beta-lifetimes of stored exotic highly charged ions** — •Fritz Bosch
SYPS 2.1	Fr	14:00–14:30	A 001	**Exciting and ionizing trapped highly charged ions with electrons and photons in an EBIT** — •José R. Crespo Lopéz-Urrutia
SYPS 2.2	Fr	14:30–15:00	A 001	**Precision x-ray spectroscopy of intense laser-plasma interaction experiments** — •Nigel Woolsey

Sessions

A 1.1–1.4	Mo	14:00–16:00	F 303	**COLTRIMS-based Collision Physics (exchanged with A4)**
A 2.1–2.8	Mo	14:00–16:00	F 107	**Atomic Systems in External Fields I**
A 3.1–3.8	Mo	14:00–16:00	A 320	**Ultra-Cold Atoms: Trapping and Cooling (with Q)**
A 4.1–4.6	Mo	16:30–18:30	F 303	**Photoionization I (exchanged with A1)**
A 5.1–5.9	Mo	16:30–19:00	A 320	**Ultra-Cold Atoms: Rydberg Gases / Miscellaneous (with Q)**
A 6.1–6.7	Tu	14:00–16:00	F 303	**Ultra-Cold Atoms, Ions and BEC I (with Q)**
A 7.1–7.8	Tu	14:00–16:00	A 320	**Ultra-Cold Atoms: Manipulation and Detection (with Q)**
A 8.1–8.56	Tu	16:30–19:00	Lichthof	**Poster I**
A 9.1–9.8	We	10:30–12:30	F 303	**Ultra-Cold Atoms, Ions and BEC II (with Q)**
A 10.1–10.7	We	10:30–12:30	F 107	**Precision Spectroscopy of Atoms and Ions I**
A 11.1–11.8	We	10:30–12:30	B 302	**Interaction with VUV and X-Ray Light I**
A 12.1–12.6	We	14:00–16:00	F 303	**Atomic Clusters I**
A 13.1–13.7	We	14:00–16:00	F 107	**Interaction with Strong or Short Laser Pulses I**
A 14.1–14.5	We	16:30–18:15	F 303	**Atomic Clusters II**
A 15.1–15.8	We	16:30–18:30	F 107	**Attosecond Physics I**
A 16.1–16.4	We	16:30–17:45	A 320	**Ultra-Cold Atoms: Single Atoms (with Q)**
A 17.1–17.8	Th	10:30–12:30	F 303	**Ultra-Cold Atoms, Ions and BEC III (with Q)**
A 18.1–18.9	Th	10:30–12:45	F 107	**Precision Spectroscopy of Atoms and Ions II**
A 19.1–19.7	Th	10:30–12:30	B 302	**Ultra-Cold Plasmas and Rydberg System**
A 20.1–20.6	Th	14:00–16:00	F 303	**Atomic Clusters III (with MO)**
A 21.1–21.7	Th	14:00–16:00	F 107	**Interaction with Strong or Short Laser Pulses I**
A 22.1–22.4	Th	14:00–15:00	F 142	**Cold Molecules (with MO)**
A 23.1–23.57	Th	16:30–19:00	Lichthof	**Poster II**
A 24.1–24.5	Fr	10:30–12:15	F 303	**Atomic Clusters IV**
A 25.1–25.9	Fr	10:30–12:45	F 107	**Precision Spectroscopy of Atoms and Ions III**
A 26.1–26.7	Fr	10:30–12:45	B 302	**Electron Scattering and Recombination / Interaction of Matter with Ions (with MO)**
A 27.1–27.7	Fr	14:00–15:45	F 303	**Ultra-Cold Atoms, Ions and BEC IV / Interaction with VUV and X-Ray Light II (with Q)**
A 28.1–28.7	Fr	14:00–15:45	F 107	**Attosecond Physics II / Interaction with Strong or Short Laser Pulses III**
A 29.1–29.8	Fr	14:00–16:00	B 302	**Atomic Systems in External Fields II**

Mitgliederversammlung Fachverband Atomphysik

Mittwoch 13:30–14:00 F 303

- Bericht
- Verschiedenes

A 1: COLTRIMS-based Collision Physics (exchanged with A4)

Time: Monday 14:00–16:00 Location: F 303

Invited Talk A 1.1 Mo 14:00 F 303
Quantum Dynamics Visualized by Reaction Microscopes: From intense virtual towards real attosecond photon fields — •Joachim Ullrich and Robert Moshammer — Max Planck Institut für Kernphysik; Heidelberg, Germany

Reaction Microscopes (REMI) image the vector momenta of low-energy electrons in coincidence with those of the ions (cold target recoil-ion momentum spectroscopy: COLTRIMS). They were developed in 1994 to explore the quantum dynamics of atomic or molecular fragmentation in fast heavy-ion collisions, motivated by tumour therapy at GSI. Ever since, kinematically complete experiments delivered surprising results, some of them understood by interpreting the field of the (relativistic) ion as a super-intense (up to 10**22 W/cm**2), attosecond virtual-photon field. About one decade later, the free-electron laser at Hamburg (FLASH) delivered first real-photon, few-femtosecond pulses. In summer 2009, up to 10**19 W/cm**2 at 2 keV photon energies were demonstrated at the LCLS (Stanford) with attosecond flashes coming into reach. Again, REMIs play a key role to investigate many-particle quantum dynamics: Multi-photon non-linear processes or time-dependent molecular reactions accessed in pioneering pump-probe experiments. In the talk, the two scenarios will be compared, key-experiments are highlighted and the rich future potential of the method is envisaged: Magneto-optical trap based REMIs in new storage rings promise achieving unprecedented momentum resolutions in ion collisions whereas REMIs completed by large-area scattered and fluorescent photon detectors deliver first exciting results at the LCLS.

Invited Talk A 1.2 Mo 14:30 F 303
Strong Field Dynamics Studied with Ion and Electron Momentum Imaging — •Lewis Cocke, Dipanwita Ray, Sankar De, Wei Cao, Guillaume Laurent, ChiiDong Lin, AT Le, Zhangjin Chen, Feng He, and Uwe Thumm — J.R.Macdonald Laboratory, Kansas State University, Manhattan,KS, USA

Some applications of momentum imaging of electrons and ions (Cold Target Recoil Ion Momentum Spectroscopy/Reaction Microcscope/Velocity Map Imaging) to problems in the interaction of short intense laser pulses with atoms and light molecules will be discussed. Examples include:

(1) Diffraction patterns characteristic of the elastic scattering of free electrons from singly ionized atoms are seen in the backscattering plateau of electrons ejected by intense lasers from rare-gas atoms. These can be analyzed in terms of the QRS (Quantitative Rescattering) model of Lin et al.

(2) The asymmetric dissociation of molecular deuterium by the combined action of a short EUV attosecond pulse train in the presence of a weak infrared field is observed when only one attosecond pulse per IR cycle is used.

(3) The dissociation of CO through autoionizing states of the cation is modified by the addition of an infrared field to the EUV attosecond pulse train which initially ionizes/excited the molecule.

Invited Talk A 1.3 Mo 15:00 F 303
Breaking the longest bond – Photoionization of the Helium Dimer — •R. Dörner[1], T. Havermeier[1], H. Sann[1], T. Jahnke[1], M. Schöffler[1], J. Titze[1], N. Neumann[1], K. Kreidi[1], R. Wallauer[1], S. Voss[1], L. Ph. H. Schmidt[1], H. Schmidt-Böcking[1], R. Grisenti[1] und W. Schöllkopf[2] — [1]J. W. Goethe-Universität Frankfurt, Max von Laue Str. 1, D-60438 Frankfurt am Main — [2]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin

The Helium Dimer He_2 is an extreme quantum system, bound with only 100neV of binding energy and a widely smeared wavefunction, showing a mean internuclear distance of 52 Angstrom. We study the photoionization of this quantum system by means of the COLTRIMS technique. We find surprisingly efficient mechanisms by which a single photon can lead to ejection of two electrons, one from each of the distant atom of the dimer.

Invited Talk A 1.4 Mo 15:30 F 303
Complete (e,2e) experiments with COLTRIMS — •Alexander Dorn — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Due to the unique versatility of the COLTRIMS technique the dynamics of atomic and molecular reactions involving all kinds of projectiles covering charged particle- and photon-beams can be explored in utmost detail. Here its application to the study of electron collisions is reviewed. Some exemplary experiments include the investigation of strongly correlated few-body coulomb systems in the continuum which are produced close to the single- or double-ionization thresholds. For ionization of diatomic molecules the collision dynamics is observed to depend on the molecular axis alignment. Furthermore, collisions embedded in intense laser pulses were studied. Finally the current endeavors to perform experiments for ionization by positron impact will be discussed.

A 2: Atomic Systems in External Fields I

Time: Monday 14:00–16:00 Location: F 107

A 2.1 Mo 14:00 F 107
Pseudo-classical Theory for Fidelity of Kicked Ultracold Atoms — •Benedikt Probst[1], Italo Guarneri[2], and Sandro Wimberger[1] — [1]Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 19, D-69120 Heidelberg — [2]Centre for Nonlinear and Complex Systems, Universitá degli Studi dell'Insubria, Via Valleggio 11, I-22100 Como

Fidelity, the overlap of two wave functions evolved with slightly different Hamiltonians, constitutes a sensitive measure to probe the dynamical evolution of a quantum system. We investigate the energy absorption of (ultra)cold atoms periodically kicked by an optical lattice, which is a realization of the famous quantum kicked rotor. We study this model in a regime with classical completely chaotic dynamics. In the vicinity of resonant kicking, the problem maps, however, to a pseudo-classical system, which allows us to apply semi-classical methods. In this case we can use semi-classics on a nearly integrable phase space to describe the quantum behaviour. Based on this pseudo-classical model, we analytically predict the occurrence of revivals for the fidelity. These revivals can be understood as recurrences in the pseudo-classical phase space. Our predictions are supported by numerical simulations. Moreover, a possible experimental verification is discussed.

A 2.2 Mo 14:15 F 107
Effective potentials in a density functional theory via local force equations — •Michael Ruggenthaler[1,2] and Dieter Bauer[1] — [1]Institut für Physik, Universität Rostock, 18057 Rostock — [2]Max-Planck-Institut für Kernphysik, 69117 Heidelberg

Time-dependent density functional theory reformulates usual wave-function-based time-dependent quantum mechanics in terms of the simple one-particle density alone [1]. The basis of a time-dependent Kohn-Sham (KS) scheme, i.e., mapping the interacting many-body problem uniquely to an auxiliary system of fictitious noninteracting particles, was given in the van Leeuwen theorem [2]. However, the van Leeuwen theorem does merely prove the uniqueness of an effective KS potential. The existence of such a potential, given via the local force balance equation of quantum mechanics, was not further investigated. We find conditions for the existence of an effective potential and prove its existence under certain restrictions [3]. Further, by expressing the interacting wave-function in terms of the noninteracting KS wave-function we find differential equations for the local Hartree-exchange and the local correlation potential [4]. Under certain assumptions we give explicit expressions for both potentials and compare the local Hartree-exchange-only approximation with the exact-exchange approximation.

[1]E.Runge and E.K.U.Gross, Phys.Rev.Lett. 52, 997 (1984)

[2]R.Van Leeuwen, Phys.Rev.Lett. 82, 3863 (1999)
[3]M.Ruggenthaler,M.Penz,D.Bauer, J.Phys.A 42, 425207 (2009)
[4]M.Ruggenthaler and D.Bauer, Phys.Rev.A 80, 052502 (2009)

A 2.3 Mo 14:30 F 107

^{3}He/^{129}Xe Uhrenvergleichsexperimente: Tests fundamentaler Symmetrie mit höchster Präzision — •Kathlynne Tullney[1], Claudia Gemmel[1], Werner Heil[1], Kai Lenz[1], Christian Ludiwig[1], Sergej Karpuk[1], Yuri Sobolev[1], Martin Burghoff[2], Silvia Knappe-Grüneberg[2], Wolfgang Kilian[2], Wolfgang Müller[2], Allard Schnabel[2], Frank Seifert[2], Lutz Thrams[2] und Stefan Baessler[3] — [1]Universität Mainz — [2]PTB Berlin — [3]University of Virginia

Die freie Spinpräzession von polarisiertem ^{3}He und ^{129}Xe Gas, welche mit hochempfindlichen SQUIDs detektiert wird, erlaubt hochpräzise Messungen von Magnetfeldern bis hinab in den 10^{-4} fT Bereich. Die hohe Empfindlichkeit wird erreicht durch die langen Spinkohärenzzeiten (transversale Relaxationszeit) von mehreren Tagen und durch das hohe Signal-Rausch Verhältnis von über 5000:1. Die Experimente wurden am BMSR-2 (magnetisch abgeschirmter Raum) an der PTB in Berlin durchgeführt. Mischt man beide polarisierten Gase, können so genannte Uhrenvergleichsexperimente durchgeführt werden. Durch Bildung der mit den gyromagnetischen Verhältnissen gewichteten Differenz der Larmorfrequenzen eliminiert man den Zeeman-Term und wird somit empfindlich auf nicht-magnetische Wechselwirkungen. So sind diese Uhren äußerst sensitiv auf eine mögliche siderische Variation der Spinpräzessionsfrequenz aufgrund der Verletzung der Lorentzinvarianz, oder dem Nachweis eines elektrischen Dipolmoments von ^{129}Xe. In diesem Vortrag werden die technische Realisierung vorgestellt, sowie erste Resultate aus den Uhrenvergleichsexperimenten gezeigt.

A 2.4 Mo 14:45 F 107

Polarization transfer in the inner–shell photoionization of sodium–like ions — •Lalita Sharma[1,2], Andrey Surzhykov[1,2], Mokhtar K Inal[3], and Stephan Fritzsche[2,4] — [1]Physikalisches Institut der Universität Heidelberg — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH — [3]Départment de Physique, Université A. Belkaid, Tlemcen, Algeria — [4]Department of Physical Sciences, University of Oulu, Finland

Density matrix formalism based on Dirac's relativistic equation has been applied to study the characteristic emission following the inner–shell photoionization of many–electron ions. In our theoretical analysis, emphasis is placed on the question how the polarization of the incident light affects the polarization of the characteristic radiation. Detailed computations have been carried out, in particular, for two electric dipole $2p^5 3s\ ^1P_1 \rightarrow 2p^6\ ^1S_0$ and $2p^5 3s\ ^3P_1 \rightarrow 2p^6\ ^1S_0$ as well as one magnetic quadrupole $2p^5 3s\ ^3P_2 \rightarrow 2p^6\ ^1S_0$ transitions following the ionization of the $2p$ electron from the sodium–like Fe^{15+} and U^{81+} ions by linearly polarized light. From these calculations, it is shown that the (degree of) linear polarization of the characteristic radiation may be enhanced by a factor of two due to the polarization transfer from the incident light. In addition to the polarization transfer, higher–order (nondipole) terms in the electron–photon interaction as well as cascade feeding from higher levels are found to have strong influence on the polarization of the subsequently emitted photons.

A 2.5 Mo 15:00 F 107

Low-Field Mobilities in the Lanthanide Region — •Mustapha Laatiaoui[1], Dieter Habs[1], Hartmut Backe[2], and Werner Lauth[2] — [1]Uni München (LMU), Fakultät für Physik, 85748 Garching — [2]Uni Mainz, Institut für Kernphysik, 55099 Mainz

In the past, Ion Mobility Spectrometry (IMS) devices have proven to be powerful tools for state-selective mobility investigations at a variety of elements [1, 2]. Hence, the mobility spectrometry increasingly gains importance if dealing with the heaviest elements, where relativistic effects strongly affect their valence electron configurations [3]. The aim of this contribution is to give an overview of low-field mobilities of rare-earth metals, where the electronic configuration is expected to be influenced by such relativistic effects. Most of the measured mobilities have shown a great similarity except for the element gadolinium. This observed deviation is assumed to be a direct consequence of occupying the *d*-orbital in gadolinium, which in turn has a big impact on its corresponding ion-atom interaction potential. This work is supported by the BMBF(06ML236I).

[1] P. Kemper et al., J. Am. Chem. Soc. 112 (1990) 3231.
[2] C. Iceman et al., J. Am. Soc. Mass Spectrom. 18 (2007) 1196.
[3] P. Indelicato et al., Eur. Phys. J. D 45 (2007) 155.

A 2.6 Mo 15:15 F 107

A canonical transforms approach to the numerical solution of time-dependent quantum wave equations — •Heiko Bauke and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The dynamics of quantum systems is governed by quantum wave equations, which are analytically tractable in rare cases only. Therefore, efficient numerical algorithms are a major tool for the investigation of quantum dynamical processes in atomic systems and others.

The Shannon sampling theorem induces limits that bound the performance of algorithms for the numerical propagation of quantum wave functions. Algorithms are fundamentally limited by the wave-function's energy spectrum as well as its momentum spectrum. However, these spectra depend on the wave-function's Hilbert-space representation and, therefore, the efficiency of numerical propagation schemes depends on the Hilbert-space representation. We demonstrate how canonical transforms may be utilized to transform the wave function into a space where it has energy and momentum spectra with reduced band width. This may increase the performance of numerical algorithms by up to several orders of magnitude. Our approach includes the so-called Kramers-Henneberger transform as a special case and puts forward modifications towards an improved numerical efficiency.

[1] Heiko Bauke and Christoph H. Keitel, Phys. Rev. E **80**, 016706 (2009)

A 2.7 Mo 15:30 F 107

Entwicklung homogener Magnetfelder für Handhabung und Transport von kernspinpolarisierten Gasen (Spinkoffer) — •Sergei Karpuk, Stefan Hiebel, Werner Heil, Jochen Krimmer, Ernst Otten und Zahir Salhi — Institut für Physik, Universität Mainz

Die Magnetresonanztomographie mit hyperpolarisierten Gasen ist inzwischen ein etabliertes medizinisches Bildgebungsverfahren. Die ^{3}He-Polarisationsanlage in Mainz ist weltweit die einzige, welche über eine medizinische Zulassung im Rahmen des Arzneimittelproduktgesetzes verfügt und für Humanstudien eingesetzt werden darf. Das kernspinpolarisierte ^{3}He wird in relaxationsarme Zellen abgefüllt und in magnetisch abschirmenden Zylindern mit dem homogenen Führungsfeld von 1 mT an Kliniken und Forschungseinrichtungen weltweit verschickt.

Angesichts von Transportzeiten bis zu 40 Stunden wurden permanent magnetisierte, wie auch stromgetriebene Spinkoffer mit einer restlichen relativen Feldinhomogenität (gradB)/B $< 10^{-3}$/cm entwickelt, die eine gradientenbedingte Relaxationszeit von mehr als 400 Stunden garantiert. Das neue Verfahren zur Homogenisierung eines eingeschlossenen, permanenten Magnetfelds beruht auf der Stetigkeit seiner Parallelkomponente an der Grenzfläche zu dem parallel zur Feldrichtung magnetisierten Zylindermantel des Spinkoffers. Dabei müssen Streuflusseffekte durch Anpassung der Manteldicke kompensiert werden. Die Stirnflächen des Zylinders dienen als Polflächen. Beim stromgetriebenen Spinkoffer genügt es, ein Solenoid eng in einen Zylinder aus Mu-Metall einzupassen, um die geforderte Homogenität zu erreichen.

A 2.8 Mo 15:45 F 107

Homogenisierung des magnetischen Führungsfeldes für die Polarisation von ^{3}He in einer kompakten Anlage — •Christian Mrozik[1], Sergej Karpuk[1], Werner Heil[1], Ernst Otten[1], Theo Schneider[2], Max Beckenbach[2], Marion Kläser[2] und Stefan Hiebel[3] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz — [2]Institut für technische Physik, Karlsruher Institut für Technologie — [3]Seckels GmbH, 61239 Ober-Mörlen

Zur Herstellung kernspinpolarisierten ^{3}He-Gases für die Grundlagenforschung sowie der Bildgebung in der Medizin dient seit 10 Jahren in Mainz eine zentrale Polarisationsanlage nach dem Prinzip des metastabilen optischen Pumpens in einem ^{3}He-Niederdruckplasma bei einem Führungsfeld von 1 mT. Die bisherige Magnetfeldquelle aus Ringspulen erreichte die erforderliche Homogenität von $\frac{\nabla B}{B} < 2 \cdot 10^{-4}\,\mathrm{cm}^{-1}$ nur in einem kleinen Volumenbruchteil und bot keine Abschirmung gegen Störfelder. Beides führte zu großen Abmessungen. Ein neues Konzept für eine weiträumige Homogenisierung und komplette Abschirmung des Magnetfelds ermöglicht nun den Bau eines kompakteren, auch für den dezentralen Einsatz beim Anwender geeigneten, Polarisators. Hierzu wurde ein Solenoid von 2 m Länge und 0,8 m Durchmesser eng in einen Zylinder aus weichmagnetischem Material eingepasst. Der gesamte Innenraum bietet nun eine hinreichende Feldhomogenität für die

Aufnahme aller Bauteile zum Polarisieren des ^{3}He. Eine Stirnfläche ist als Tür zur Entnahme des polarisierten Gases ausgelegt, die andere bietet durch eine kaminartige und mit einer Korrekturspule versehene Öffnung Zugang zur Tragekonstruktion und zu Versorgungsleitungen.

A 3: Ultra-Cold Atoms: Trapping and Cooling (with Q)

Time: Monday 14:00–16:00 Location: A 320

A 3.1 Mo 14:00 A 320

Shortcut to adiabaticity: fast optimal frictionless atom cooling in harmonic traps — •Andreas Ruschhaupt — Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany

A method is proposed to cool down atoms in a harmonic trap as in a perfectly slow adiabatic expansion but in a much shorter time. This is achieved by designing the time dependence of the trap frequency, the harmonic trap may even become an expulsive parabolic potential in some time interval. The resulting cooling times have no fundamental lower bound and are shorter than previous minimal times using optimal-control bang-bang methods and real frequencies.

Ref.: [1] Xi Chen, A. Ruschhaupt, S. Schmidt, A. del Campo, D. Guery-Odelin and J. G. Muga, arXiv:0910.0709v1 [quant-ph]

[2] J. G. Muga, Xi Chen, A. Ruschhaupt and D. Guery-Odelin, J. Phys. B: At. Mol. Opt. Phys. 42 (2009) 241001 (FTC)

A 3.2 Mo 14:15 A 320

Fiber-pigtailed atoms — •Daniel Reitz, Rudolf Mitsch, Melanie Müller, Eugen Vetsch, Samuel T. Dawkins, and Arno Rauschenbeutel — QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz

We present our recent results on trapping laser-cooled cesium atoms around a subwavelength-diameter optical nanofiber. The atoms are localized in the evanescent field in a 1d optical lattice, created by blue- and a red-detuned laser beams, launched through the fiber. We detect the atoms by measuring the absorption of a weak resonant probe beam, sent through the fiber, which couples to the atoms via the evanescent field. Remarkably, the ensemble of 2000 trapped atoms is optically dense. Furthermore, we demonstrate a fiber-based optical conveyor belt. For this purpose, the two counter-propagating red-detuned beams are mutally detuned, thereby setting the optical lattice in motion and transporting the atoms along the fiber. Finally, we demonstrate an interferometric measurement of the optical phase shift due to the atomic ensemble. Our technique opens the route towards the direct integration of laser-cooled atomic ensembles within fiber networks, an important prerequisite for large scale quantum communication schemes. Moreover, it is ideally suited to the realization of hybrid quantum systems that combine atoms with, e.g., solid state quantum devices.

Financial support by the ESF (EURYI Award) and the Volkswagen Foundation (Lichtenberg Professorship) is gratefully acknowledged.

A 3.3 Mo 14:30 A 320

Laser cooling of a magnetically guided ultra cold atom beam — •Anoush Aghajani-Talesh, Markus Falkenau, Valentin Volchkov, Axel Griesmaier, and Tilman Pfau — Universität Stuttgart, 5. Physikalisches Institut

We report on the transverse laser cooling of a magnetically guided beam of ultra cold chromium atoms. Radial compression by a tapering of the guide is employed to adiabatically heat the beam. Subsequently, heat is extracted from the atom beam by a two-dimensional optical molasses perpendicular to it, resulting in a significant increase of atomic phase space density. A magnetic offset field is applied to prevent optical pumping to untrapped states. Our results demonstrate that by a suitable choice of the magnetic offset field, the cooling beam intensity and detuning, atom losses and longitudinal heating can be avoided. Final temperatures below 65 μK have been achieved, corresponding to an increase of phase space density in the guided beam by more than a factor of 30. We discuss the resulting implications for the loading of a optical dipole trap from the beam [1].

[1] A Aghajani-Talesh, M Falkenau, A Griesmaier, and T Pfau. A proposal for continuous loading of an optical dipole trap with magnetically guided ultra cold atoms. *J. Phys. B.* **42** 245302 (2009).

A 3.4 Mo 14:45 A 320

A miniaturized microwave guide for electrons — •Johannes Hoffrogge and Peter Hommelhoff — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching bei München

We are currently setting up an experiment aiming at guiding electrons in an AC quadrupole guide. The use of miniaturized trapping structures allows for an exceptional tight confinement in the transverse direction. In combination with a single atom tip as electron source, electron injection near the transverse ground state of motion may become feasible. This would lead to a well-defined motional quantum system with potential applications in, e.g. electron interferometry. While ion traps are driven at radiofrequencies, the stable confinement of electrons demands operation at microwave frequencies because of their much higher charge to mass ratio. This can be accomplished by the combination of the electrode layout of a microfabricated planar Paul trap with that of a microwave transmission line on a planar substrate. In stark contrast to the case of ion traps, for a guide with a length comparable to the wavelength of the driving field, the microwave guiding properties of the trap structure become important. Here, we show results of a detailed microwave analysis of a planar five wire structure driven at 1 GHz. As another important element of the experiment, an optimized incoupling structure for a smooth transition from the field free region to the trapping field will be dicussed. We also present experimental results of a first realization with trap frequencies around 100 MHz and radial trap dimensions of several hundred micrometers.

A 3.5 Mo 15:00 A 320

Stopping particles of arbitrary velocities with an accelerated wall — •Sönke Schmidt[1], J. Gonzalo Muga[2], and Andreas Ruschhaupt[1] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover, Germany — [2]Departamento de Quimica Fisica, UPV-EHU, Bilbao, Spain

We propose a method to stop a pulse of particles with different velocities by making them collide with an accelerated wall with trajectory proportional to the square root of time. We discuss the ideal one-dimensional case. Then we generalize the model to three dimensions and different geometries of the potential wall to give a more realistic description. Finally we show the efficiency of the method.

A 3.6 Mo 15:15 A 320

Kalte neutrale Quecksilberatome in einer MOT — •Sebastian Siol, Patrick Villwock, Mathias Sinther und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, AG Laser und Quantenoptik, Schlossgartenstr. 7, 64289 Darmstadt

Quecksilber hat fünf stabile bosonische und zwei stabile fermionische Isotope, die sich fangen und kühlen lassen. Die fermionischen Isotope eignen sich zur Untersuchung eines neuen optischen Zeitstandards. Zusätzlich bietet eine magneto-optische Falle die Möglichkeit durch Photoassoziation translatorisch kalte Hg-Dimere herzustellen und in den vibratorischen Grundzustand zu kühlen.

Die Sättigungsintensität des Kühlübergangs bei 253,7 nm beträgt 10,2 mW/cm^2, bei einer natürlichen Linienbreite von 1,27 MHz. Durch die zweistufige externe Frequenzverdopplung eines Yb:YAG Scheibenlasers bei 1014,9 nm kann eine UV-Leistung von bis zu 280 mW bereitgestellt werden. Zur Frequenzstabilisierung des Lasers wird ein entsprechendes Fehlersignal durch dopplerfreie Sättigungsspektroskopie in Kombination mit Frequenzmodulationsspektroskopie generiert. Es wurden Atomzahlen von bis zu (3,2±0,3)x10^6 erreicht. Bei einem mittleren Wolkenradius von (250±18) μm entspricht dies einer Atomdichte von (4,8±1,4)x10^{10} Atome/cm^3.

Neben der experimentellen Realisierung der magneto-optischen Falle werden die jüngsten Ergebnisse sowie interessante Anwendungsmöglichkeiten diskutiert.

A 3.7 Mo 15:30 A 320

Manipulation of atoms with optical tweezers — •Lukas Brandt, Cecilia Muldoon, Tobias Thiele, Jian Dong, and Axel Kuhn — University of Oxford, Clarendon Laboratory, Parks Road,

Oxford OX1 3PU, UK

In many implementations of quantum information processing schemes, the control of individual qubits relies on the ability to arbitrarily manipulate, address and couple individual information carriers, like single atoms or single photons. Here, we report on a novel dipole-trapping experiment that will ultimately allow to trap single neutral atoms in separate dipole traps and to displace them individually.

In order to reach a high degree of control on single atoms, we are implementing a scheme that enables us to trap ^{87}Rb atoms in an array of individual optical dipole-traps. These dipole-traps are created by imaging the surface of a digital light-modulator. The light-modulator is a digital micro-mirror device (DMD) whose surface consists of 1024 x 768 micro-mirrors. The micro-mirrors can be individually switched. By switching the micro-mirrors, the dipole-trap array can be dynamically rearranged. The DMD is imaged by an isoplanatic optical system [1], which is diffraction limited with a numerical aperture of NA=0.5 and thus is able to focus the light to a submicron spot size.

Recently we have observed trapping of atoms in separate dipole traps. This is the first step towards an array of trapped individual atoms.

[1] E. Brainis et. al., Optics Communication 282, 465 (2009)

A 3.8 Mo 15:45 A 320

Laser cooling of atoms by collisional redistribution of radiation — •Anne Sass, Ulrich Vogl, and Martin Weitz — Institut für Angewandte Physik der Universität Bonn, Wegelerstraße 8, D-53115 Bonn

The general idea that optical radiation may cool matter was put forward by Pringsheim already in 1929. Doppler cooling of dilute atomic gases is an extremely successful application of this concept, and more recently anti-Stokes fluorescence cooling in multilevel systems has been explored. We experimentally demonstrate cooling of an atomic gas by collisional redistribution of fluorescence, a technique based on the atomic two level system, using rubidium atoms subject to 200 bar of argon gas pressure. The frequent collisions in the ultradense gas transiently shift a far red detuned laser beam into resonance, while spontaneous decay occurs close to the unperturbed atomic resonance frequency. During each excitation cycle, a kinetic energy of order of the thermal energy $k_{\mathrm{B}}T$ is extracted from the dense atomic sample. We presently achieve cooling in a heated gas from an initial temperature of 410 °C down to −120 °C temperature in the laser beam focus. The cooled gas has a density of more than 10 orders of magnitude above the typical values in Doppler cooling experiments. Future prospects of the demonstrated technique can include cryocoolers and the study of homogeneous nucleation in saturated vapour.

A 4: Photoionization I (exchanged with A1)

Time: Monday 16:30–18:30 Location: F 303

Invited Talk A 4.1 Mo 16:30 F 303

A hitherto unrecognized source of low-energy electrons in water — •Melanie Mucke[1], Markus Braune[2], Silko Barth[1], Marko Förstel[1,3], Toralf Lischke[1], Volker Ulrich[1], Tiberiu Arion[1], Uwe Becker[2], Alex M. Bradshaw[1,2], and Uwe Hergenhahn[1] — [1]Max-Planck-Institut für Plasmaphysik, EURATOM association, Boltzmannstr. 2, 85748 Garching — [2]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin — [3]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Our experiments focus on the investigation of water clusters by electron-electron coincidence spectroscopy. The clusters were generated by supersonic molecular expansion of water vapour. After photoionisation of an inner valence electron by synchrotron radiation (BESSY, Berlin) an ultrafast non-local autoionisation process can occur. This so-called Intermolecular Coulombic Decay (ICD) leads to the ejection of two electrons, a photoelectron from molecule A and an electron of very low kinetic energy emerging from molecule B within the same cluster. This process is faster than a possible proton transfer and will thus efficiently generate these slow electrons. ICD can be triggered by any radiation of sufficient energy, but may as well take place as a secondary process following e.g. Auger decay. Therefore it is easy to imagine that there will be a wealth of low energy electrons generated wherever a watery environment is given, e.g. in biological tissue, and thus radiation damage might occur.

A 4.2 Mo 17:00 F 303

Signatures of the complex classical dynamics in the spectrum of highly doubly excited states of two-electron atoms — •J. Eiglsperger, M. Schönwetter, and J. Madroñero — Physik Department, Technische Universität München, Germany

Close to the break-up threshold of two-electron atoms the spectrum is strongly influenced by the underlying classical mixed regular-chaotic dynamics and typical signatures of quantum chaos, e.g., Ericson fluctuations or scaling laws [1] for the fluctuations of the photoionization cross section (PCS), are expected to become observable.

Computations for the PCS of He and Li^+ have been performed to test the charge dependent exponent of the scaling law in [1]. A comparison of experimental data with the planar model reveals a quantitative agreement for the PCS of helium. PCS calculated up to the 25th single ionization threshold exhibit fluctuations. These are mainly due to a dominant series of resonances which can be associated with an approximate quantum number $F = N - K$ in accordance with 3D full calculations and experimental observations [2]. As the energy increases, the dominant role of a single series as sole contributor is apparently lost as new series start to contribute significantly to the cross sections. This would result in an earlier onset of Ericson fluctuations [3] than in the picture of a single dominant series, where the onset is expected around I_{34}.

[1] C. W. Byun *et al.*, Phys. Rev. Lett. **98**, 113001 (2007).
[2] Y. H. Jiang *et al.*, Phys. Rev A **78**, 021401 (2008).
[3] J. Eiglsperger and J. Madroñero, Phys. Rev A **80**, 022512 (2008).

A 4.3 Mo 17:15 F 303

Photoionization of highly charged ions in the x-ray regime — •Zoltán Harman[1,2], Martin C. Simon[1], Maria Schwarz[1], Sascha W. Epp[1], José R. Crespo López-Urrutia[1,3], Christoph H. Keitel[1], and Joachim Ullrich[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]ExtreMe Matter Institute EMMI, Planckstrasse 1, 64291 Darmstadt, Germany — [3]Max Planck Advanced Study Group, Center for Free-Electron Laser Science, Luruper Chaussee 149, 22761 Hamburg, Germany

Photoionization (PI) of multiply and highly charged ions is studied theoretically by means of the multiconfiguration Dirac-Fock (MCDF) method and experimentally using an electron beam ion trap and synchrotron radiation at the BESSY II electron storage ring. The method introduced here extends the range of ions accessible for PI investigations. Experimental data on near-threshold and resonant PI of N^{3+}, Ar^{8+} and Fe^{14+} ions, species of astrophysical and fundamental interest, show high resolution and accuracy, and agree with the present and other advanced theoretical approaches at the level of 0.1 eV at 800 eV.

A 4.4 Mo 17:30 F 303

Dissociation of protonated water clusters after x-ray ionization — •Christian Domesle[1], Lutz Lammich[2], Henrik B. Pedersen[2], Brandon Jordon-Thaden[1], Marko Förstel[3], Tiberiu Arion[3], Toralf Lischke[3], Uwe Hergenhahn[3], Stefan Klumpp[4], Michael Martins[4], Oded Heber[5], and Andreas Wolf[1] — [1]Max-Planck Institut für Kernphysik, Heidelberg, Germany — [2]University of Aarhus, Denmark — [3]Max-Planck Institut fuer Plasmaphysik, Garching, Germany — [4]Universität Hamburg, Germany — [5]Weizmann Institute of Science, Rehovot, Israel

Protonated water clusters are important systems in interstellar and planetary atmospheric environments. Moreover, studies of their properties in the gas phase elucidate the elementary mechanisms behind the mobility of free charges in aqueous surroundings. Soft x-rays give access to the excited electronic orbitals of these systems and their role in the fragmentation dynamics. With the FEL light source (FLASH) at DESY and the ion beam infrastructure TIFF, the observation and imaging of individual fragmentations triggered by soft x-ray absorption on dilute gas-phase targets of these ionic species has become possible. We investigated the photoionization and subsequent fragmentation of

$H^+(H_2O)_2$. At TIFF the serial arrangement of two MCP detectors with delay-line readout allowed for time, position and coincidence investigations of the fragments. By means of time of flight analysis the fragments could be clearly indentified. Coincident events on both detectors give first information on the expected final decay channels.

A 4.5 Mo 17:45 F 303

Precise Determination of Valence Photoionisation Properties - From Precision Electron Spectroscopy to Molecular Two-Centre Interferences — •Markus Ilchen[1], Markus Braune[2], Sascha Deinert[1], Leif Glaser[1], Frank Scholz[1], Peter Walter[1], and Jens Viefhaus[1] — [1]Deutsches Elektronen Synchrotron, 22067 Hamburg — [2]Fritz-Haber-Institut, 14195 Berlin

Angle resolved photoelectron spectroscopy was performed with an online analysis tool which has been set up for determining several beamline parameters of the P04 beamline at PETRA III, DESY. The device is capable of giving users an online feedback of e.g. the degree of polarization within seconds without affecting the beam. Building a precise database of anisotropy parameters β for many gases in a wide energy range is the basis for this task. An intrinsic benefit of this method is that actual literature is evaluated and complex phenomena can be analysed in detail. Highly precise angle resolving measurements for the valence photoionization of N_2 and O_2 are presented in a low energy range from 19 - 50 eV in comparison to other authors [1,2]. Concerning the data calibration, modified data for the β-literature of Neon [3] is presented. In a collaboration with the Fritz-Haber-Institut, additional measurements of N_2 and O_2 in a wider energy range show Cohen-Fano oscillations due to interference of two-centre electron emission [4].

[1] S.H. Southworth et al, Phys. Rev. A **33** (1986) 1020.
[2] I. Iga et al, J. Phys. B **22** (1989) 2991.
[3] F. Wuilleumier and M.O. Krause, JESRP **15** (1976) 15.
[4] H.D. Cohen and U. Fano, Phys. Rev. **150** (1966) 30.

Invited Talk A 4.6 Mo 18:00 F 303

Two-Center Interference in Valence Photoionization of N_2 and O_2 — •Markus Braune[1], Markus Ilchen[2], Sanja Korica[1], Andre Meissner[1], Lokesh Tribedi[1], Sascha Deinert[2], Leif Glaser[2], Frank Scholz[2], Peter Walter[2], Jens Viefhaus[2], and Uwe Becker[1] — [1]Fritz-Haber-Institut, 14195 Berlin — [2]DESY, 22607 Hamburg

Cohen and Fano derived their famous formula for the oscillation of the partial cross sections of homonuclear diatomic molecules in 1966 [1]. The oscillatory behavior in the valence photoionization of N_2 and O_2 which they presented as experimental evidence turned out to be basically an intensity variation due to a shape resonance rather than a signature of coherent emission from two emitter sites. The oscillation period of a real Cohen-Fano type oscillation depends on the internuclear distance and extends over a broad energy range as has been proven many years later for the 1s core photoionization of H_2 [2] and N_2 [3]. Most recently, we analyzed the valence photoionization of N_2 and O_2 used as an example by Cohen and Fano by means of angular resolved photoelectron spectroscopy in a collaboration with DESY. We present first data of Cohen-Fano oscillations concerning outer valence partial cross sections and angular distribution asymmetry parameters. The results are compared with recent theoretical calculations [4].

[1] Cohen H D and Fano U, Phys. Rev. 150, 30 (1966)
[2] N. Stolterfoht et al., Phys. Rev. Lett. 87, 23201 (2001).
[3] B. Zimmermann et al., NPhys. 4, 649 (2008)
[4] D. Toffoli, P. Decleva, J. Phys. B 39, 2681 (2006)

A 5: Ultra-Cold Atoms: Rydberg Gases / Miscellaneous (with Q)

Time: Monday 16:30–19:00 Location: A 320

Prize Talk A 5.1 Mo 16:30 A 320

Highly excited atoms in cold environments: From antihydrogen production to ultracold plasmas and Rydberg gases — •Thomas Pohl — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden — Laureate of the Gustav-Hertz-Prize

The production of cold antihydrogen atoms at CERN marks a major development in AMO as well particle physics, as it holds great promise for high precession-spectroscopy tests of CPT invariance and for investigating matter-antimatter gravity. Since they form in highly excited states, successful cooling and trapping of antihydrogen atoms relies on the special properties of Rydberg atoms and how they form in the strong magnetic fields of anti-matter plasma traps.

Here, I will report on recent progress in understanding the formation of Rydberg atoms in antihydrogen traps as well as in ultracold neutral plasmas, as produced from laser-cooled atomic gases. This also includes fundamental questions concerning the nature of recombination processes in ultracold, so-called strongly coupled systems and is important for pushing the temperature limits of Rydberg plasmas. Controlling the temperature in ultracold plasmas and Rydberg gases is shown to open up a diverse range of interesting phenomena, such as dynamical crystallization processes in the classical as well as in the quantum domain.

A 5.2 Mo 17:00 A 320

Coherent population trapping with controlled interparticle interactions — •Georg Günter[1], Hanna Schempp[1], Christian Giese[1], Sebastian Saliba[1], Christoph Hofmann[1], Brett D. DePaola[1], Sevilay Sevincli[2], Thomas Pohl[2], Thomas Amthor[1], and Matthias Weidemüller[1] — [1]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg — [2]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Strasse 38, 01187 Dresden

Coherent population trapping (CPT) and the related phenomenon of a "dark resonance" is a paradigm for quantum interference. Intense studies of this phenomenon have led to intriguing effects like electromagnetically induced transparency, lasing without inversion, adiabatic population transfer and subrecoil cooling. Whereas CPT is generally described within a single-atom framework, the situation becomes more involved when interparticle interactions have to be considered. To address this question, we investigate CPT in a strongly interacting, ultracold Rydberg-gas. In our experiment we tune the interaction strength by choosing the Rydberg state and control interactions effects using the ground state density. Even in the blockade regime we observe a resonance with sub-natural linewidth at the single-particle resonance frequency despite the strong van der Waals interactions among Rydberg atoms. Due to the correlations among the atoms the experimental observations cannot be explained within a meanfield model. A theoretical model that includes interparticle correlations is presented and nicely reproduces the observed features.

A 5.3 Mo 17:15 A 320

Semiclassical analysis of Rydberg molecules — •Gordana Palavestric, Jörg Main, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart, 70550 Stuttgart

In cold gases ultra-long range Rydberg molecules have been predicted theoretically [1] and recently observed experimentally [2]. The molecular binding can be described with a Fermi pseudo-potential and the Born-Oppenheimer approximation. We present a semiclassical model to describe the interaction. The electron of the highly excited Rydberg atom is scattered at the ground state atom. The transferred momentum causes a force on the neutral atom. We solve the classical equations of motion and investigate the initial condition for the bound dynamics of the "Rydberg molecule".

[1] C. H. Green, A. S. Dickinson, H. R. Sadeghpour, Phys. Rev. Lett. **85**, 2458 (2000).
[2] V. Bendkowsky, B. Butscher, J. Nipper, J. P. Shaffer, R. Löw and T. Pfau, Nature **458**, 1005 (2009).

A 5.4 Mo 17:30 A 320

Strongly interacting Rydberg atoms in a one-dimensional lattice — •Hendrik Weimer and Hans Peter Büchler — Institut für Theoretische Physik III, Universität Stuttgart

We analyze the ground state properties of a one-dimensional lattice system, where Rydberg excitations are created by laser driving. In the classical limit the ground state is characterized by comensurate crystals with fractional exciations. We show that quantum fluctuations lead to a melting of the crystalline phases that is governed by condensation of the excitations. We compare the critical exponents obtained within perturbation theory to mean-field predictions for a homogeneous gas [1,2].

[1] H. Weimer, et al., Phys. Rev. Lett. **101**, 250601 (2008).
[2] R. Löw et al., Phys. Rev. A **80**, 033422 (2009).

A 5.5 Mo 17:45 A 320

Antiblockade of Rydberg excitation in an ultracold gas — •Christoph S. Hofmann[1], Thomas Amthor[1], Christian Giese[2], Georg Günter[1], Hanna Schempp[1], Nele Müller[1], and Matthias Weidemüller[1] — [1]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg — [2]Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

The long-range character of strong Rydberg–Rydberg interactions gives rise to phenomena such as the interaction-induced blockade of Rydberg excitation. The opposite effect, the so-called antiblockade of excitation has recently been proposed for a three-level two-photon Rydberg excitation scheme, in which an Autler-Townes splitting is induced by strong coupling laser at the lower transition [1]. When the coupling energy matches the interaction energy of the long-range Rydberg interactions, the otherwise blocked excitation of close pairs becomes possible. We present the first experimental observation of the antiblockade in an ultracold Rydberg gas [2]. To reveal this effect we use time-resolved ionization detection. In this way we monitor the distribution of excited-pair distances, which allows us to clearly observe additional excitation (antiblockade) of pairs at small distances out of a random arrangement of atoms. A model based on a pair interaction Hamiltonian is presented which nicely reproduces our experimental observations and allows to analyze the distribution of nearest neighbor distances.

[1] C. Ates et al., Phys. Rev. Lett 98, 023002 (2007)
[2] T. Amthor et al., arXiv:0909.0837v1

A 5.6 Mo 18:00 A 320

Occupation statistics of a Bose-Einstein condensate in a driven double-well potential — •Moritz Hiller[1], Katrina Smith-Mannschott[2,3], Maya Chuchem[4], Tsampikos Kottos[2], and Doron Cohen[4] — [1]Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg — [2]Department of Physics, Wesleyan University, CT, USA — [3]MPI für Dynamik und Selbstorganisation, Bunsenstraße 10, 37073 Göttingen — [4]Department of Physics, Ben-Gurion University, Beer-Sheva, Israel

We consider the occupation statistics $P_t(n)$ of a Bose-Einstein condensate consisting of N particles loaded in a double-well trap with inter-site coupling K. Two dynamical scenarios are investigated: a) wave-packet dynamics and b) linear variation of the bias between the on-site energies of the two wells. In the latter case, we resolve three different behaviors as we increase the driving rate for intermediate values of the inter-atomic interaction $K/N < U < NK$: quantum adiabatic, diabatic, and sudden regime. We find that during the adiabatic to diabatic crossover, many-body Landau-Zener transitions play a dominant role, resulting in oscillations of the second moment of the occupation statistics. In contrast, the crossover to the sudden regime is characterized by a broad distribution $P_{t\to\infty}(n)$ which is reflected in a global maximum of its second moment.

A 5.7 Mo 18:15 A 320

Spectral origin of decaying Bloch oscillations — •Hannah Venzl, Moritz Hiller, and Andreas Buchleitner — Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

We study Bloch oscillations of ultra-cold bosonic atoms in tilted optical lattices. Our analysis is based on the Bose-Hubbard Hamiltonian amended by a static field term. For comparable values of the control parameters, namely the inter-atomic interaction, the inter-site hopping amplitude, and the static field, the system displays chaotic level statistics. In this regime, the Bloch oscillations exhibit an irreversible, fast decay. We discuss how the corresponding decay rate can be obtained from the spectral properties of the Bose-Hubbard Hamiltonian.

A 5.8 Mo 18:30 A 320

Probing a Bose-Hubbard system with a scattering particle — •Stefan Hunn[1], Moritz Hiller[1], Tsampikos Kottos[2,3], Doron Cohen[4], and Andreas Buchleitner[1] — [1]Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg — [2]Department of Physics, Wesleyan University, CT, USA — [3]MPI für Dynamik und Selbstorganisation, Bunsenstrasse 10, 37073 Göttingen — [4]Department of Physics, Ben-Gurion University, Beer-Sheva, Israel

We consider a probe particle in a tight-binding geometry with two leads attached to a central site that is coupled to a Bose-Hubbard system consisting of two or three wells. We find that the characteristic properties of the target's underlying phase-space structure are reflected in the scattering signal. Hence, this scattering setup constitutes a non-destructive method to measure the properties of a Bose-Einstein condensate confined on an optical lattice. We focus on the parameter regime where the corresponding classical dynamics is chaotic and follow a three-fold approach to the scattering process: Besides the quantum mechanical scattering theory we employ an improved random matrix model and propose a time-dependent, semi-classical formulation of the scattering process where the Bose-Hubbard Hamiltonian is treated in the mean-field (Gross-Pitaevskii) limit.

A 5.9 Mo 18:45 A 320

Connecting ultra hot with ultra cold: geometric phases in cold atoms — •Michael Merkl[1], Patrik Öhberg[1], Luis Santos[2], and Gediminas Juzeliunas[3] — [1]Heriot-Watt University Edinburgh — [2]Universität Hannover — [3]Vilnius University

Ultra-cold atoms have turned out to be an ideal playground for testing quantum physics. Recently analogies between ultra-cold systems and high energy physics have attracted a great interest. For kinetic energies below the photon recoil limit, the internal electronic states can be said to follow the optical field and hence a Berry phase emerges in the atom's centre of mass Schrödinger equation. Moreover, for a degenerate manifold of electronic states the geometric phase describes transitions within this pseudo-spin Hilbert space, which can also give rise to non-Abelian effects. In this work we show how a wide range of phenomena like Josephson effects, mass currents and soliton like objects in the presence of geometric gauge potentials can occur. These techniques can also be used to mimic aspects of relativistic quantum mechanics with cold atoms.

A 6: Ultra-Cold Atoms, Ions and BEC I (with Q)

Time: Tuesday 14:00–16:00 Location: F 303

Invited Talk A 6.1 Tu 14:00 F 303

Probing weakly bound molecules with nonresonant light — •Mikhail Lemeshko and Bretislav Friedrich — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, D-14195 Berlin, Germany

We show that weakly-bound molecules, such as those created via Feshbach resonances or photoassociation of ultracold atoms, can be accurately probed by "shaking" in a pulsed nonresonant laser field. The technique relies on the ability to impart a tunable value of angular momentum to the weakly bound molecule such that the centrifugal term concomitant with it expels the molecule's vibrational level from the potential and thus causes the molecule to dissociate. The laser intensity needed to impart a preordained value of the angular momentum varies characteristically with the internuclear distance. It is this characteristic dependence that can be used to map out the probability density of the vibrational state from which the molecule was forced to dissociate. A highly accurate long-range molecular potential can then be retrieved by inverting the vibrational probability density. This route to an accurate potential, independent of spectroscopy or scattering, complements what can be learned from either. We illustrate the technique's machinery by examining Feshbach molecules of acute interest, Rb2 and KRb. In addition, we discuss the possibilities to control the molecular size, the positions of Feshbach resonances, and the photoassociation probability using cw laser fields, and note that the laser field of an optical dipole trap may dissociate some of the most weakly bound molecules via the "shaking" mechanism.

A 6.2 Tu 14:30 F 303

Bragg Spectroscopy of Ultracold Bosons in an Optical Lat-

tice — •Ulf Bissbort, Yongqiang Li, and Walter Hofstetter — Institut für Theoretische Physik, Goethe Universität Frankfurt

In recent experiments [1,2] it has become possible to probe an interacting atomic gas of ultracold atoms in an optical lattice using Bragg spectroscopy, allowing energy and momentum to be resolved independently within the same measurement. We simulate these experiments under realistic conditions using the time-dependent bosonic Gutzwiller method, which, in contrast to Gross-Pitaevskii theory, captures depletion effects and becomes exact in both the non-interacting and strongly interacting limit. Furthermore, in contrast to static mean-field theory, it is capable of describing correlated excitations, such as Goldstone modes, and is numerically efficient, allowing simulations for all experimentally feasible time scales. In the limit of weak interactions Bogoliubov theory (including trap effects) is recovered, whereas in the case of strong interactions close to the Mott insulating border, a gapped amplitude mode is found to dominate, which has not yet been observed in experiments.

[1] P. Ernst et al., arXiv:0908.4242 (2009).
[2] D. Clément et al., Phys. Rev. Lett. **102**, 155301 (2009).

A 6.3 Tu 14:45 F 303

Lattice-Ramp Induced Dynamics in an Interacting Bose-Bose Mixture at Zero and Finite Temperature — •Julia Wernsdorfer[1], Michiel Snoek[2], and Walter Hofstetter[1] — [1]Institut für Theoretische Physik , Goethe-Universität, Max-von-Laue-Str. 1, 60438 Frankfurt am Main, Deutschland — [2]Instituut voor Theoretische Fysica, Universiteit van Amsterdam, 1018 XE Amsterdam, Netherlands

In this work we model recent experiments [1] on an interacting 87Rb-41K bosonic gas in an optical lattice at zero and finite temperature. In particular we investigate the dynamics induced by the lattice-ramp up, which is an unavoidable step in the experimental procedure. Using the Gutzwiller mean-field method we examine whether the induced dynamics brings the system out of thermal equilibirum. We explain the experimentally observed oscillations in the visibility by relating them to the issue of adiabaticity [2].

[1] J. Catani, L. De Sarlo, G. Barontini, F. Minardi, and M. Inguscio, *Degenerate Bose-Bose mixture in a three-dimensional optical lattice*, Phys. Rev. A **77**, 011603 (R) (2008)
[2] J. Wernsdorfer, M. Snoek, and W. Hofstetter, *Lattice-Ramp Induced Dynamics in an Interacting Bose-Bose Mixture*, arXiv:0911.0697v1 (2009)

A 6.4 Tu 15:00 F 303

Injection Locking of a Trapped Ion Phonon Laser — •Valentin Batteiger[1], Sebastian Knünz[1], Maximilian Herrmann[1], Guido Saathoff[1], Theodor W. Hänsch[1], Thomas Udem[1], and Kerry Vahala[2] — [1]Max-Planck-Institut für Quantenoptik, Garching, Germany — [2]California Institute of Technology, Pasadena, CA, USA

A single trapped ion is addressed by two laser beams, one tuned below, one above an atomic resonance. This opto-mechanical system can perform stable self-sustained oscillations, which we describe in close analogy to optical lasers [1]. We show the basic operation principle and present injection locking of the ion's motion to an externally controlled signal. Reference: [1] K. Vahala et al., Nature Physics 5, 682 (2009).

A 6.5 Tu 15:15 F 303

Correlation versus commensurability effects for finite bosonic systems in one-dimensional lattices — •Ioannis Brouzos — Zentrum fuer Optische Quantentechnologien, Luruper Chaussee 149, 22761 Hamburg, Germany

We investigate few-boson systems in finite one-dimensional multi-well traps covering the full interaction crossover from uncorrelated to fermionised particles. Our treatment of the ground state properties is based on a numerically exact multi-configurational time-dependent method. For commensurate filling we trace the fingerprints of localisation, as the interaction strength increases, in several observables like local and non-local densities, fluctuations and momentum distribution. In addition for filling factor larger than one we observe on-site repulsion effects and other features of the physics beyond the Bose-Hubbard model regime approaching the Tonks-Girardau limit. The presence of an incommensurate fraction of particles induces partial delocalisation and spatial modulations of the profiles, taking into account the finite size of the system.

A 6.6 Tu 15:30 F 303

Cooling into the spin-nematic state for a spin-1 Bose gas in an optical lattice — •Ming-Chiang Chung — National Center for Theoretical Sciences, Hsinchu, Taiwan

The possibility of adiabatically cooling a spin-1 polar Bose gas to a spin-nematic phase is theoretically discussed. The relation between the order parameter of the final spin-nematic phase and the starting temperature of the spinor Bose gas is obtained both using the mean-field approach for high temperature and spin-wave approach for low temperature. We find that there exists a good possibility to reach the spin-nematic ordering starting with spinor antiferromagnetic Bose gases.

A 6.7 Tu 15:45 F 303

The Efimov effect in heteronuclear systems — •Kerstin Helfrich and Hans-Werner Hammer — Helmholtz-Institut für Strahlen- und Kernphysik and Bethe Center for Theoretical Physics, Universität Bonn, 53115 Bonn, Germany

Ultracold quantum gases with large scattering length show resonant enhancement of three-body loss rates when an Efimov trimer is at the scattering threshold. We calculate the three-body loss rates in heteronuclear mixtures of atoms for the case of large scattering length between the unlike atoms. Using zero-range interactions, we present results from the numerical solution of the integral equations for the recombination amplitude in momentum space and extract expressions for the recombination rate constants. Moreover, we calculate the relative positions of loss features for different sign of the scattering length and a first comparison with available experimental data is shown.

A 7: Ultra-Cold Atoms: Manipulation and Detection (with Q)

Time: Tuesday 14:00–16:00 Location: A 320

A 7.1 Tu 14:00 A 320

Interactions of atoms with spatially dispersive solids — •Harald Haakh[1], Carsten Henkel[1], and Baruch Horovitz[2] — [1]Universität Potsdam, Germany — [2]Ben Gurion University of the Negev, Beer Sheva, Israel

We discuss the coupling of atoms and ions to solid surfaces, in particular superconductors and metals. This is relevant for the anomalous heating in miniaturized ion traps and for spin flip rates of magnetic traps implemented on microchips, which determine the trap stability. Our approach is based on the surface response of spatially dispersive media, relevant for vortex lattices in type-II superconductors and the anomalous skin effect. We identify in particular the relevance of the scattering mean free path of the carriers in the solid, as compared to the distance of observation by the atom. Different boundary conditions for the current density (specular vs. diffuse) are generalized to the relevant parameter regime (non-retarded transverse response).

A 7.2 Tu 14:15 A 320

A new Experiment for the investigation of ultra-cold Potassium Rubidium Mixtures — •Georg Kleine Büning, Johannes Will, Jan Peise, Wolfgang Ertmer, and Jan Arlt — Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover

We present an experimental apparatus, which will allow us to investigate mixtures of ^{87}Rb with the bosonic isotopes of potassium ^{39}K or ^{41}K, and also enable the use of Feshbach-resonances.

In the experiment the desired isotopes are collected in a magneto-optical trap from the background vapour. A magnetic quadrupole trap is used to transport the pre-cooled atoms mechanically into a glass cell with better vacuum. There the atoms are transferred into a novel hybrid optical and magnetic trap. Subsequently sympathetic cooling will be used to bring the desired isotopes of rubidium and potassium to quantum degeneracy. Finally a magnetic field can be tuned to the Feshbach resonances to manipulate the interaction strength.

Particular attention will be given to the design of the novel hybrid trap, which recently allowed for the realisation of a BEC of about 10^6 ^{87}Rb atoms.

A 7.3 Tu 14:30 A 320

Evaporative cooling in a magnetic trap strongly distorted by gravitation — •Matthias Wolke, Julian Klinner, and Andreas Hemmerich — Universität Hamburg

Due to experimental constraints our cigar-shaped magnetic trap has to operate with its weak confinement along the direction of gravity. We present the first Bose-Einstein-Condensate via RF-induced evaporative cooling in this scenario. Differences between this setup and the conventional setup with its weak trapping axis in the horizontal direction are discussed. In our setup different Zeeman-species display a macroscopic difference in gravitational sag. We present data, which show that this has significant impact on the evaporation efficiency.

A 7.4 Tu 14:45 A 320

Collective atom-cavity effects with cold Ytterbium gases. — Matteo Cristiani[1], Hannes Gothe[1], Tristan Valenzuela[1], and •Jürgen Eschner[1,2] — [1]ICFO - Institut de Ciencies Fotoniques, Mediterranean Technology Park, 08860 Castelldefels (Barcelona), Spain — [2]FR Experimentalphysik, Universität des Saarlandes, Campus E2.6, 66123 Saarbrücken

We report results from an experiment aiming at collective dynamics of a cold atomic ensemble coupled to the mode of an ultra-high finesse Fabry-Perot cavity. In our experiment we cool and trap $\approx 10^6$ Yb atoms in a MOT using the $^1S_0 \rightarrow {}^1P_1$ transition at 399 nm. The cloud temperature is $T = 2\,\mathrm{mK}$. Around the cloud position we have set up a high finesse cavity with length $L = 4.74\,\mathrm{cm}$, linewidth $\kappa = 2\pi \times 60\,\mathrm{kHz}$ and finesse $\mathcal{F} = 55000$. We study the action of the atomic cloud on the cavity mode and observe a behaviour which indicates the presence of strong collective atom-photon coupling. The effects of the cavity mode on the atomic dynamics (cavity cooling and self-organization) are under investigation.

A 7.5 Tu 15:00 A 320

Matter Wave Scattering from Ultracold Atoms in an Optical Lattice — Scott N. Sanders[1,2], •Florian Mintert[3], and Eric J. Heller[1] — [1]Physics Department, Harvard University — [2]Massachusetts Institute of Technology — [3]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg

We study matter wave scattering from an ultracold, many body atomic system trapped in an optical lattice. The angular cross section of the target lattice for a matter wave is determined and is demonstrated to have a strong dependence on the many body phase, superfluid or Mott insulator. Analytical approaches are employed deep in the superfluid and Mott insulator regimes, while intermediate points in the phase transition are treated numerically. Matter wave scattering offers a convenient method for non-destructively probing the quantum many body phase transition of atoms in an optical lattice.

A 7.6 Tu 15:15 A 320

Towards phase damping of two independent condensates via an optical high finesse cavity — •Simone Bux, Christine Gnahm, Gordon Krenz, Claus Zimmermann, and Philippe A.W. Courteille — Physikalisches Institut Tübingen, Auf der Morgenstelle 14, 72076 Tübingen

Optical ring cavities have been proposed for novel optical cooling schemes for atoms and molecules known as "cavity-cooling" [1,2]. However, they also play an important role in the quest for controllable damping mechanisms working even for superfluids, whose prominent feature is the absence of friction. Our goal is to experimentally prove the viability of a cavity-based damping scheme predicted to lead to the unification of independently grown Bose-Einstein condensates (BEC) [3]. For this purpose, we create in our experiment two BECs of Rb87 in two different hyperfine states. The states are coherently driven on a microwave-radiofrequency two-photon transition and additionally coupled by a Raman transition, which is stimulated by a high-finesse ring cavity. This scheme induces an irreversible cycling in the atomic excitation and, due to the cavity-mediated coupling to the external degrees of freedom, a synchronization of the condensates' de Broglie phases. We will present the model and the state of the art of our experiment.

[1] V. Vuletic and S. Chu, Phys. Rev. Lett. 84, 3787 (2000)
[2] P. Horak, S. M. Barnett, and H. Ritsch, Phys. Rev. A 61, 033609 (2000)
[3] D. Jaksch, S. A. Gardiner, K. Schulze, J. I. Cirac, and P. Zoller, Phys. Rev. Lett. 86, 4733 (2001)

A 7.7 Tu 15:30 A 320

Dissipative manipulation of an ultracold quantum gas — •Andreas Vogler[1,2], Peter Würtz[1], Tatjana Gericke[1], Tobias Weber[1,2], Fabian Etzold[1], Frank Markert[1], and Herwig Ott[1,2] — [1]Institut für Physik, Johannes-Gutenberg Universität, Mainz — [2]Fachbereich Physik, Technische Universität Kaiserslautern

We present an experimental investigation of dissipative effects, affecting a cloud of ultracold Rb-atoms.

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, the electron-beam is a versatile tool capable of applying particle dissipation on the atomic ensemble. We can vary the atomic losses on individual positions by controlling the dwell time. By choosing the correct scan-pattern we are able to perturb the atomic cloud either on distinct places or homogeneously.

The temporal analysis of the detected ions allows us to determine cross-sections of electron-atom scattering as well as observe signatures of cold ion-atom collisions. We propose this dissipative manipulation technique to study many-body effects, e.g., local and non-local particle-particle correlations.

A 7.8 Tu 15:45 A 320

A New Apparatus for Cavity QED Experiments in the Strong Coupling Regime — •Markus Koch, Christian Sames, Matthias Apel, Max Balbach, Alexander Kubanek, Alexei Ourjoumtsev, Pepijn Pinkse, Karim Murr, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, D-85748 Garching, Germany

The ability to trap single atoms in high-finesse cavities in the strong coupling regime has stimulated the field of cavity QED, leading to the observation of many long predicted effects such as the normal-mode splitting, two-photon resonances or cavity cooling. We present the status of a new apparatus to continue this line of research.

It features an asymmetric cavity, which significantly enhances the photon flux from the cavity. In addition, coned mirrors provide transverse optical access to the trapped atom. Finally, a piezo motor allows to adjust the length of the cavity macroscopically, thus enabling to study cavity QED effects over a broad range of cavity parameters.

First measurements of the normal modes as well as of the intensity response of the system are presented. We observe considerably increased storage times compared to previous experiments, mandatory for further investigations, e.g. nonlinear optics at the single-particle level.

A 8: Poster I

Time: Tuesday 16:30–19:00 Location: Lichthof

A 8.1 Tu 16:30 Lichthof

General mechanisms of electron dynamics in FEL-irradiated clusters — •Christian Gnodtke, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden

We describe the dynamics of electrons in clusters induced by radiation from free-electron lasers (FEL). Based on a simple molecular dynamics model with only four parameters, the total number of ionization events, the cluster radius, the atomic excess energy of the dominant ionization process and the pulse duration, we study the electron motion microscopically. The general dynamics may be categorized into four main parameter regions distinguished by the degree of electron trapping as well as the cross-over from sequential to non-sequential ionization. We identify within this parameter space the previously studied cases of a trapped equilibrium [1] and non-equilibrium plasma [2] as well as the regime of sequential ionization of the cluster [3]. Of particular interest is the region of non-sequential ionization with high excess energy for which we observe the novel phenomenon of ultra-fast formation of an exponential spectrum of the electrons, indicative of an equilibration of the electron system in the continuum.

[1] Ch. Bostedt et al. (experiment), U. Saalmann et al. (theory), to be published

[2] U. Saalmann et al., New J. Physics **10**, 025014 (2008)

[3] Ch. Bostedt et al., Phys. Rev. Lett. **100**, 133401 (2008)

A 8.2 Tu 16:30 Lichthof

Shortcomings of Lindemann-like melting criteria in finite systems — •Jens Böning, Torben Ott, and Michael Bonitz — Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität, Leibnizstr. 15, D-24098 Kiel, Germany

For numerical studies of phase transitions, a rich variety of so called Lindemann and Lindemann-like criteria exists. Their popularity is mostly due to their simplicity, especially for numerical implementation. They are found to work reasonably well even in finite few-particle systems where no strict phases exist [1], which is also reflected in a softening in other melting criteria like the specific heat or magnetic moment. In this work, we provide an overview over available Lindemann-like parameters and their limitations. We focus on the *mean relative distance fluctuations* also known as *Berry parameter* which is often seen as Lindemann-like but differs fundamentally [2]. We demonstrate that this parameter is inherently flawed and requires renormalization to a universal time-scale [3].

[1] F. Baletto and R. Ferrando, *Rev. Mod. Phys.* **77**, 371 (2005)
[2] D.D. Frantz, *J. Chem. Phys.* **115**, 6136 (2001)
[3] J. Böning et al., *Phys. Rev. Lett.* **100**, 113401 (2008)

A 8.3 Tu 16:30 Lichthof

Studies of rare-gas clusters in intense IR laser fields — •Siva Rama Krishnan[1], Bettina Fischer[1], Manuel Kremer[1], Robert Moshammer[1], Joachim Ullrich[1], Jagannath Jha[2], and Krishnamurthy Manchikanti[2] — [1]Max Planck Insitut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Tata Institute of Fundamental Research, 1 Homi Bhabha Road, Mumbai 400005, India

We report studies on the dynamics of Argon clusters in intense IR femtosecond laser fields. These were carried out at intensities of $\sim 10^{15} W.cm^{-2}$ and a central wavelength of $800nm$ using a Ti:Sapphire based femtosecond laser system delivering $25fs$ pulses. Clusters with a log-normal size-distribution were generated by the supersonic expansion of Argon gas with sizes ranging from 10^3-10^5 atoms/cluster. We present results on kinetic energy spectra of ions and electrons from time-of-flight measurements. The general characteristics of the ion spectra compare well with earlier investigations on rare-gas clusters. We also compare these spectra with appropriate theoretical models which incorporate the final Coulomb explosion of charged clusters taking into account the distribution of cluster sizes in the target and the distribution of intensities in the laser focus.

A 8.4 Tu 16:30 Lichthof

Resolution enhancement in the magnetic bottle photoelectron spectrometer (PES) by means of a time-variable potential step — •Moritz Weigt and Bernd von Issendorff — Universität Freiburg

We present a new method for improving the resolution of a magnetic bottle photoelectron spectrometer. This is achieved by a time-variable potential step which the electrons cross after a certain part of their flightpath.

Normally, a number of effects lead to electrons of the same velocity and emission time being distributed in a packet of finite length. This leads to a distribution of arrival times at the detector, limiting the precision of the time-of-flight measurement.

The time-variable potential time-focuses these electron packets in the detector plane, in principle eliminating this measurement error. It can be shown that this correction is equally valid for all electron energies, in contrast to other methods using pulsed fields for resolution enhancement.

A PES using the new method is currently under construction and, according to detailed simulations, could achieve an energy resolution of at least 1/300 for electron energies between 0.25 and 10 eV. This would mean an improvement by a factor of 5 to 10 compared to the existing setup.

A 8.5 Tu 16:30 Lichthof

Clusters in XUV laser pulses: Electron emission and nanoplasma dynamics — •Mathias Arbeiter und Thomas Fennel — Institute of Physics, University of Rostock

The ionization dynamics of Argon clusters in ultrashort and intense XUV laser pulses is investigated by molecular dynamics simulation. Corresponding experiments[1] at FLASH free electron laser at $\lambda = 32$ nm and $\lambda = 13$ nm with intensities of $I = 10^{12-14}$ W/cm^2 have demonstrated the cluster response to be completely different to the behavior observed in the infrared and the VUV regime, where plasma heating processes dominate the laser- cluster coupling. In contrast, energy absorption due to the excitation of localized electrons, i.e. by the inner ionization processes itself, becomes increasingly important at high photon energy. The resulting signatures in electron energy spectra can be described by a multi-step ionization scheme as long as photoelectrons can escape directly from the cluster potential. Beyond this point, thermalization becomes the dominant process for further electron emission, as is demonstrated by corresponding simulation results.[2] From these scenarios, promising future experiments will be addressed for XUV pump-and-probe experiments, e.g. for monitoring nanoplasma built-up, cluster expansion and dark plasmon modes.

[1] C. Bostedt et al., Phys. Rev. Lett. 100, 133401 (2008)
[2] M. Arbeiter, Th. Fennel, in preparation

A 8.6 Tu 16:30 Lichthof

Core-level Photoelectron Spectroscopy on Free Mass-Selected Metal Clusters at FLASH — •V. Senz[1], T. Fischer[2], P. Oelssner[1], J. Bahn[1], A. Kickermann[1], M. Köther[1], J. Neville[3], M. Schöffler[4], L. Foucar[4], H. Thomas[5], S. Schorb[5], M. Neeb[6], J. Tiggesbäumker[1], M. Martins[7], E. Rühl[8], C. Bostedt[5], W. Eberhardt[6], M. Götz[2], G. Ganteför[2], T. Möller[5], H. Schmidt-Böcking[4], R. Dörner[4], W. Wurth[7], and K.-H. Meiwes-Broer[1] — [1]I. f. Physik, U Rostock — [2]FB Physik, U Konstanz — [3]University of New Brunswick, Canada — [4]I. f. Kernphysik, U Frankfurt — [5]I. f. Optik und Atomare Physik, TU Berlin — [6]Helmholtz-Zentrum Berlin — [7]I. f. Experimentalphysik, U Hamburg — [8]Phys. u. Theor. Chemie, FU Berlin

The electronic structure forms the basis for understanding and tailoring the physical and chemical properties of clusters. A promising method to study this issue is core-level photoelectron spectroscopy using the VUV free-electron laser FLASH at DESY. Our results on lead clusters feature a size-dependent 5d core-level shift and reveal a remarkable change of final state screening conditions due to a metal-to-nonmetal transition at a cluster size of 20 atoms. The interplay of geometry, bonding character and final state electron relaxation and screening of these finite size systems could be experimentally accessed and may challenge theoretical treatment [Phys. Rev. Lett. 102, 138303 (2009)]. In addition, first results on Au 4f spectroscopy will be discussed. A new experimental setup using a hemispherical electron spectrometer leading to improved energy resolution will be presented.

A 8.7 Tu 16:30 Lichthof

Entwicklng einer 1” Magnetronquelle zur Realisierung einer kompakten Clusterdepositionsapparatur — •Martin Pichotka — FMF Freiburg

Wir stellen die Characteristika einer Maschine zur Deposition von geladenen metallischen Clustern vor. Die Maschine besitzt eine neuentwickelte, kompakte 1” Magnetron-Sputterquelle, ein Ionenführungs- und Massenselektionssystem, bestehend aus einer Anordnung von Octopolführung und Quadrupolselektor. Alternativ zur Quadrupolselektion kann ein Energieselektor, zur Selektion großer Cluster, oder auch ausschliesslich eine Octopolführung verwendet werden. Ein in den Strahlengang einführbarer Probenhalter kann zur Realisierung verschiedener Depostionsenergien auf Potential gelegt werden. Der Strahl kann ohne Veränderung der Quell- und Selektor- bwz. Führungsparameter in ein TOF-Spektrometer eingeschossen werden. Das Spektrometer, bestehend aus einem Reflektron und Even-Cup-Detektor, dient zur Kontrolle der selektierten Clustergrössen sowie zur Charakterisierung der Quelleneigenschaften. Mit diesem System wurde die Clusterproduktion der 1” Quelle in Abhängigkeit der Quellparameter untersucht.

A 8.8 Tu 16:30 Lichthof

Untersuchung der Transferionisation und des doppelten Elektroneneinfangs mit Heliumdimeren — •Jasmin Titze[1], Markus Schöffler[2], Nadine Neumann[1], Hong-Keun Kim[1], Florian Trinter[1], Markus Waitz[1], Jörg Voigtsberger[1], Matthias Odenweller[1], Birte Ullrich[1], Robert Wallauer[1], Lutz Foucar[4], Katharina Kreidi[3], Till Jahnke[1], Achim Czasch[1,5], Lothar Ph. H. Schmidt[1], Robert Grisenti[1], Ottmar Jagutzki[1,5], Reinhard Dörner[1] und Horst Schmidt-Böcking[1] — [1]Institut für Kernphysik Frankfurt, Goethe-Universität Frankfurt, Max-von-Laue-Str. 1, 60438 Frankfurt — [2]Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße1, 64291 Darmstadt — [4]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [5]RoentDek Handels GmbH, c/o Institut für Kernphysik, Max-von-Laue-Str. 1, 60438 Frankfurt am Main

Heliumdimere stellen das am weitesten gebundene atomare System dar. Seine Größe ist mit der eines DNA Moleküls vergleichbar. In Stößen mit Alphateilchen bei Projektilenergien von 150 keV/u wurde die Zerfallsdynamik von Heliumdimeren untersucht. Es wurden hierzu zwei Reaktionskanäle gleichzeitig vermessen, der doppelte Elektroneneinfang und die Transferionsation. Als Messtechnik wurde die COLTRIMS-Technik (COLd Target Recoil Ion Momentum Spectroscopy)verwendet. In den Ergebnissen zeigen sich 3 voneinander unterscheidbare Zerfallsprozesse.

A 8.9 Tu 16:30 Lichthof

Angle-resolved photoelectron spectroscopy of metal clusters — •Adam Piechaczek, Christian Hock, Raphael Kuhnen, Christof Bartels, and Bernd v.Issendorff — Fakultät für Mathematik und Physik, Universität Freiburg, Stefan-Meier Str.19, 79104 Freiburg

Angle and energy resolved photoelectron spectroscopy of size-selected K_{55}^-, Ag_{55}^- and Cu_{55}^- clusters has been performed. The electrons are photodetached by a ns laser pulse with photon wavelengths between 248 nm and 428 nm. The photoelectron angular distributions (PADs) of the outgoing electrons contain information about the angular momentum character of the bound state electrons. In the case of one photon excitation the PADs can be described by a single anisotropy parameter β. This parameter has been extracted for transitions from electrons detached from different bound states of the clusters as a function of photon energy. The data is compared with our results for sodium clusters [1]. When the evolutions of the betaparameter are plotted against the wavenumber k of the outgoing electrons multiplied by the clusterradius, the positions of the minima are astonishingly similar for the peaks of the 1g levels. This seems to indicate a very similar effective potential which is seen by the electron for the different clusters species. In this case the evolution of beta could possibly be described in a single active electron model.

[1] C. Bartels et al., Science **323**, 1323-1327 (2009)

A 8.10 Tu 16:30 Lichthof

High Resolution Mass Separation of Cluster Ions — •Kiran Majer[1], Lei Ma[1,2], and Bernd von Issendorff[1] — [1]Institut für Physik, Universität Freiburg, 79104 Freiburg, Germany — [2]Department of Physics, Nanjing University, 210093 Nanjing, China

In cluster physics most experiments study an observable depending on the cluster size (i. e. number of atoms or molecules composing the cluster), thus requiring an appropriated mass selection prior to the actual experiment. Our existing setup comprises a double reflector time-of-flight (TOF) mass spectrometer, with mass selection after the first reflector and a total flight length of about 4m. The achieved a mass resolution is $m/\Delta m \approx 4000$. This means for a medium sized cluster of ca. 6000 amu (e.g. Cu_{91}^-) the attachment of a hydrogen atom to the cluster can not be detected.

A straightforward approach to improve mass resolution is to increase the flight time elongating the ion flight path. To fit such a system into a common TOF apparatus, the physically given flight path must be used multiple times by reflecting the ions repeatedly between ion mirrors.

We introduce a newly build linear multi-pass reflectron composed of two coaxially arranged electrostatic mirrors. It is set up in series with our existing double reflector TOF, allowing us to enhance mass selectivity on request (according to simulations a mass resolution of 100 000 could be achieved). A comparison of the simulated and experimentally achieved resolution as well as a first application to cluster experiments will be shown.

A 8.11 Tu 16:30 Lichthof

2p-Photoionisation an freien größenselektierten Silizium-Clustern — •Marlene Vogel[1], Konstantin Hirsch[1], Andreas Langenberg[3], Jürgen Probst[1], Jochen Rittmann[3], Vicente Zamudio-Bayer[1], Jörg Wittich[1], Silvia Forin[1], Felix Ameseder[1], Bernd von Issendorff[2], Thomas Möller[1] und Tobias Lau[3] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, EW 3-1, Hardenbergstraße 36, D-10623 Berlin — [2]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg — [3]Helmholtz-Zentrum Berlin für Materialien und Energie, Institut für Methoden und Instrumentierung der Synchrotronstrahlung, Albert-Einstein-Straße 15, D-12489 Berlin

Die Röntgenspektroskopie an freien Clustern stellt aufgrund der niedrigen Targetdichte und des niedrigen Röntgenphotonen-Flusses eine Herausforderung dar. Nun ist es gelungen, Innerschalen-Röntgenspektroskopie an größenselektierten freien Siliziumclustern Si_n^+ im Größenbereich $n = 5 - 92$ an der $2p$-Kante durchzuführen. Durch die angewandte Methode, die Ionenausbeutespektroskopie, können die direkte Rumpfniveau-Photoionisation und die resonante Rumpfniveau-Anregung getrennt analysiert werden, was eine zur XPS analoge Untersuchung ermöglicht.

Die vorgestellten Ergebnisse gewähren neue interessante Einblicke in die elektronische Struktur kleiner bis mittlerer Siliziumcluster.

A 8.12 Tu 16:30 Lichthof

Resonant 2p X-ray Absorption Spectroscopy of Size Selected Calcium, Scandium, Nickel and Copper Clusters — •Felix Ameseder[2], Jochen Rittmann[1], Silvia Forin[2], Konstantin Hirsch[2], Christian Kasigkeit[2], Andreas Langenberg[1], Jürgen Probst[2], Marlene Vogel[2], Jörg Wittich[2], Vicente Zamudio-Bayer[2], Thomas Möller[2], Bernd von Issendorff[3], and Tobias Lau[1] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie, Institut für Methoden und Instrumentierung der Synchrotronstrahlung, Albert-Einstein-Str. 15, 12489 Berlin — [2]Technische Universität Berlin, Institut für Optik und Atomare Physik, Hardenbergstr. 36, 10623 Berlin — [3]Universität Freiburg, Fakultät für Physik, Stefan-Meier-Str. 21, 79104 Freiburg

Studies on the 3d transition metals in the past have revealed interesting phenomena, including a so-called 'anomalous' branching ratio of the early transition metal atoms and the development of the branching ratio from the atom to the bulk. Here we present the first resonant 2p-3d measurements of size selected calcium, early transition metals (Sc) and later transition metals (Ni, Cu). By means of resonant x-ray absorption spectroscopy on size selected clusters an insight into the development of the electronic structure of calcium (d^0), scandium (d^1), nickel (d^9) and copper (d^{10}) clusters is obtained. A detailed discussion including a comparison between the early transition metal and calcium on the one hand and the late transition metals on the other hand will be given.

A 8.13 Tu 16:30 Lichthof

VUV photoionization spectroscopy of size selected silicon and aluminium cluster cations — •Christian Kasigkeit[1], Konstantin Hirsch[1], Andreas Langenberg[2], Jochen Rittmann[2], Marlene Vogel[1], Vicente Zamudio-Bayer[1], Jürgen Probst[1], Jörg Wittich[1], Thomas Möller[1], Bernd von Issendorf[3], and Tobias Lau[2] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, EW 3-1, Hardenbergstraße 36, D-10623 Berlin, Germany — [2]Helmholtz-Zentrum Berlin für Materialien und Energie, Institut für Methoden und Instrumentierung der Synchrotronstrahlung, Wilhelm-Conrad-Röntgen Campus / BESSY II, Albert-Einstein-Straße 15, D-12489 Berlin, Germany — [3]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg, Germany

Valence band photoionization spectroscopy of free size selected silicium and aluminium cluster cations has been performed in order to determine the lth ($l = 2-5$) ionization potentials with respect to cluster size. Cluster size has therefore been varied from $n = 6$ up to $n = 92$ atoms for silicon and $n = 7$ to $n = 56$ for aluminium. The measured behavior of the ionization potentials corresponds to the liquid drop model. Charged clusters have been accumulated using a nitrogen cooled ion trap colinear to the exciting synchrotron radiation beam to obtain sufficient target density and absorption length. The spectra have been measured by detecting the ion yield of the resulting fragments.

A 8.14 Tu 16:30 Lichthof

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 8.15 Tu 16:30 Lichthof

A *Swiss army knife* for dealing with the hydrogen atom model — •Sean McConnell[1,2], Stephan Fritzsche[2,3], and Andrey Surzhykov[1,2] — [1]Physikalisches Institut der Universität Heidelberg — [2]GSI Helmholtzzentrum für Schwerionenforschung — [3]University of Oulu, Finland

Since its release in 2004, the Dirac program has become a *staple in the diet* of studies on the structure and behaviour of hydrogen–like ions [1]. With the help of this program, originally developed as a set of Maple procedures, a number of investigations were recently performed on the charge transfer in relativistic ion–atom collisions, the radiative transitions in high–Z projectiles and the spin entanglement phenomena in atomic photoionization. Here, we present a new version of the Dirac package which is designed within the framework of Mathematica [2]. While retaining all previous capabilities, the new version includes many new features and improvements. In particular, the new Mathematica procedures support the symbolic and numerical evaluation of the two–photon transition rates, Coulomb excitation cross sections and polarization properties of characteristic radiation, to name just a few. Furthermore, a built–in and interactive help system will ensure new users of Dirac can exploit the program's potential with greater ease than its predecessor.

[1] A. Surzhykov, P. Koval, and S. Fritzsche, Comput. Phys. Commun. **165** (2005) 139

[2] S. McConnell, S. Fritzsche, and A. Surzhykov, Comput. Phys. Commun. *accepted, in press*

A 8.16 Tu 16:30 Lichthof

Extension of imaginary time method for laser assisted tunneling of quasistationary states — •Héctor M. Castañeda[1], Sergey Popruzhenko[2], Adriana Pálffy[1], and Christoph H. Keitel[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Moscow State Engineering Physics Institute, Russia

The imaginary time method (ITM) [1] was originally introduced for description of nonlinear ionization in intense laser fields, or, in general, tunneling through time-dependent barriers [2]. Within ITM, the ionization process is described by classical equations of motion solved in complex time, so that the transition amplitude is determined by the respective classical action [1,2].

For atoms in the absence of an external field, the initial state is usually a true bound state and the electron cannot tunnel out freely. However, laser fields can also assist processes where tunneling occurs already without an external field, such as cold emission of electrons or decay of autoionizing states. For description of such intense-laser-assisted effects, ITM could also serve as an efficient tool. Here we extend the formalism of ITM to describe laser-assisted decay of quasistationary states and apply it to calculate the tunneling probability in the presence of an intense electromagnetic field. We show that the laser field modifies the total probability of decay and the shape of the spectrum. This opens a way to control the quasistationary state decay.

[1] V. S. Popov, V. P. Kuznetsov, and A. M. Perelomov, JETP **26**, 222 (1967)

[2] V. S. Popov, Phys. At. Nucl. 68, 686 (2005)

A 8.17 Tu 16:30 Lichthof

Efficient grid-based nonequilibrium Green's function calculations: I. General method and applications to atoms and molecules — •Karsten Balzer and Michael Bonitz — ITAP, Christian-Albrechts-Universität Kiel, Leibnizstr. 15, 24098 Kiel

For strongly inhomogeneous quantum systems, the use of finite elements (FE) in combination with the discrete variable representation (DVR) [1,2] allows for an optimal and flexible representation of the nonequilibrium Green's function (NEGF) in coordinate space [3]. In contrast to a general basis approach, the complementary features of the FE-DVR lead (i) to (semi-)analytic matrix elements of the kinetic, potential and interaction energy operators, (ii) to drastic simplifications of the self-energies and, in turn, (iii) to an essential speedup in the computation of the NEGF.

As atomic and molecular examples, we compute, in Hartree-Fock and second Born approximation, the equilibrium properties of the helium atom, the hydrogen molecule, and lithium hydride modeled in one spatial dimension [3]. The results comprise the self-consistent ground-state/binding energies, densities and bond-lengths which are compared with the solution of the few-particle time-dependent Schrödinger equation.

[1] T.N. Rescigno, and C.W. McCurdy, Phys. Rev. A 62, 032706 (2000). [2] B.I. Schneider, L.A. Collins, and S.X. Hu, Phys. Rev. E 73, 036708 (2006). [3] K. Balzer, S. Bauch, and M. Bonitz, arXiv:0910.5458, submitted to Phys. Rev. A (2009).

A 8.18 Tu 16:30 Lichthof

Efficient grid-based nonequilibrium Green's function calculations: II. Code parallelization and resolution of time-dependent atomic features — •Karsten Balzer and Michael Bonitz — ITAP, Christian-Albrechts-Universität Kiel, Leibnizstr. 15, 24098 Kiel

The real-time propagation of the nonequilibrium Green's function (NEGF) solving the two-time Schwinger/Keldysh/Kadanoff-Baym equations generally involves very large computational resources and, hence, reveals limited capabilities. For this reason, using the finite-element discrete variable representation [1-3], we develop a parallel code which gets along with minumum random access memory (RAM) at acceptable inter-node communication. The resulting program is ready for large cluster computation and should enable enhanced applicability of NEGFs in atomic problems.

As first benchmarks, we compute, in second Born approximation, the nonequilibrium behavior of the one-dimensional helium atom starting from the self-consistent (correlated) ground-state state [3]. From the time-propagation, we extract the dipole-strength and discuss one- and two-electron excitations. Also, the results are compared to solutions of the two-particle time-dependent Schrödinger equation.

[1] T.N. Rescigno, and C.W. McCurdy, Phys. Rev. A 62, 032706 (2000). [2] B.I. Schneider, L.A. Collins, and S.X. Hu, Phys. Rev. E 73, 036708 (2006). [3] K. Balzer, S. Bauch, and M. Bonitz, arXiv:0910.5458, submitted to Phys. Rev. A (2009).

A 8.19 Tu 16:30 Lichthof

Photoionization of one-dimensional model atoms — •David Hochstuhl, Sebastian Bauch, and Michael Bonitz — ITAP, Christian-Albrechts Universität zu Kiel, 24098 Kiel

Computer simulations using one-dimensional model atoms may often qualitatively reproduce experimental results, and in this way offer a great insight into the processes involved in the ionization in strong laser fields. The movement of the electrons is thereby restricted only to the polarization axis of the electromagnetic field. In particular, the one-dimensional helium atom is employed frequently in the literature, since it is able to describe several correlation effects like the double ionization knee. Simulations on larger systems are, however, only rarely encountered. The focus of this poster lies thus on the usefullness of such models.

We present numerically converged calculations for one-dimensional atoms with four and six electrons, which are obtained by the multiconfigurational time-dependent Hartree-Fock method, and compare them to results from the helium model. Further, we analyze to which extent these models are able to approximate their three-dimensional analogues beryllium resp. carbon.

A 8.20 Tu 16:30 Lichthof

Complex atoms in strong laser fields: A multiconfigurational time-dependent Hartree-Fock approach — •David Hochstuhl and Michael Bonitz — ITAP, Christian-Albrechts Universität zu Kiel, 24098 Kiel

In the last decade simulations of real, three-dimensional complex atoms in strong laser fields became feasible within several methods, e.g. convergent close coupling, time-dependent density functional theory or R-matrix methods. Here we apply the multiconfigurational time-dependent Hartree-Fock method which is, in principle, able to yield exact, i.e. numerically converged results. For the treatment of the three dimensions, we employ an expansion in spherical harmonics times a radial function, which is expanded in a Coulomb-wave discrete variable representation. The main focus of this poster lies on the capabilities and performance of this scheme. Results are presented for photoionization of the helium atom and compared to convergent close coupling calculations. Further, the beryllium atom is considered.

A 8.21 Tu 16:30 Lichthof

State dependent optical lattice and coherent motional state control of single neutral atoms — Leonid Förster, Michał Karski, Jai-Min Choi, Andreas Steffen, Noomen Belmechri, •Arif Mawardi, Kohei Katayama, Wolfgang Alt, Dieter Meschede, and Artur Widera — Institut für Angewandte Physik der Universität, Wegelerstr. 8, 53115 Bonn, Germany

In our experiment we trap neutral cesium atoms in a state dependent 1D-optical lattice. Along the tight axial-confinement, the atoms can be controllably shifted to the left or to the right depending on their hyperfine state. We use this ability for coherent manipulation of the quantized motional states using microwave radiation. We experimentally show that by adjusting the wavefunction overlap, microwaves can induce sideband transitions between any two trapped motional states. Based on this we have implemented a microwave cooling scheme which we used to achieve a ground state population of 97% along the axial degree of freedom.

Beyond single-particle effects this experiment aims on the realization of controlled coherent collisions between atoms. For this, 3D ground state population is crucial. Cooling schemes so far are limited by the weak radial confinement provided by the Gaussian profile of the trapping laser. We discuss how this limit can be bypassed by an additional blue detuned ring shaped laser beam overlapped with the original lattice and we present our preliminary progress.

A 8.22 Tu 16:30 Lichthof

Strahldiagnostik und Quellenentwicklung an Dresden EBIS/T — •Erik Ritter[1], Ulrich Kentsch[2], Johannes König[1], Vladimir Ovsyannikov[2], Mike Schmidt[2], Andreas Schwan[2], Alexandra Thorn[1], Falk Ullmann[2] und Günter Zschornack[1] — [1]Institut für Angewandte Physik, Technische Universität Dresden, Germany — [2]Dreebit GmbH, Dresden, Germany

Es werden Strahldiagnostikmessungen der longitudinalen und der transversalen Emittanz an einer Dresden EBIS-A vorgestellt. Hierfür wurden ein neu entwickelter Gegenfeldanalysator sowie ein Pepper-Pot Emittanzmesssystem verwendet. Mit einer mittleren (rms-) Emittanz von generell weniger als 10 mm mrad, und einer Energieunschärfe kleiner 0,15 eV/u wurden der EBIS exzellente Strahleigenschaften nachgewiesen. Weiter werden Fortschritte im Bereich der Ionenquellenentwicklung vorgestellt. Neue, verkürzte Extraktionslinsensysteme der Quellen bieten in Kombination mit einem E×B-Filter (Wien-Filter) die Möglichkeit, ladungszustandsseparierte Ionenstrahlen in hochkompakten Anlagen zu erzeugen. Die Verbindung der hervorragenden Strahleigenschaften einer Dresden EBIS-A mit einem kompakten Ladungszustandsfilter eröffnen neue Applikationsmöglichkeiten, beispielsweise für den Einsatz von EBIS/T Systemen in Anlagen der medizinischen Ionenstrahltherapie. Weitere Anwendungsgebiete werden aufgezeigt.

A 8.23 Tu 16:30 Lichthof

Quantum Walks and Single Atom Inteferometry with neutral atoms in a 1D lattice — •Noomen Belmechri, Michał Karski, Leonid Förster, Jai-Min Choi, Andreas Steffen, Wolfgang Alt, Dieter Meschede, and Artur Widera — Institut für Angewandte Physik der Universität Bonn Wegelerstraße 8, 53115 Bonn, Germany.

We present applications of state-dependent transport in a 1D optical lattice, in particular matter-wave interference starting from a single atom. Individual Cs atoms are trapped in a standing wave that is composed of two polarizations acting independently on the two qubit states. By displacing the sublattices, we coherently transport atoms across several μm and spatially split the wavefunction of superposition states. Repeated application of a $\frac{\pi}{2}$-pulse and a transport step realizes a quantum walk with up to 24 steps, allowing us to observe superclassical spreading of the walk as well as recombination to a single site by unitary reversal. Adding state-selective detection, a full state tomography could be performed. The decoherence sources limiting the walk have been investigated.

We also split and recombine an individual atomic wavefunction, reading out the phase difference. In the presence of a magnetic gradient, the phase accumulation incorporates the Zeeman shift difference, making the atom interferometer the basis for a local magnetic field probe. We report on our characterization of the phase evolution caused by the lattice shift operation and our results in a strong gradient.

A 8.24 Tu 16:30 Lichthof

Exploring attosecond experiments beyond single active electron — •Sebastian Bauch and Michael Bonitz — Christian-Albrechts-Universität Kiel, Institut für Theoretische Physik und Astrophysik, Leibnizstraße 15, 24098 Kiel, Germany

Experimental achievements in the last decade allow for the creation and control of high-harmonics generated attosecond light pulses [1]. Among the most exciting applications of this technique is the exploration of time-resolved electronic processes inside atoms, including the dynamics of electronic correlations. One milestone-experiment addresses the time-resolved exploration of shake-up state population via strong-field tunneling [2]. Owing to the weak intensity of the xuv pulse, a strong probing infrared pulse is used, leading to a significant perturbation of the electronic structure of the atom and the corresponding laser induced transitions. To describe these phenomena beyond the commonly used single-active electron approximation, we solve the time-dependent Schrödinger equation for a two-electron model atom. We present results for experiment-alike situations and compare our model to single-active electron calculations with a sudden approximation for the xuv pulse. Our approach allows for a systematic investigation of the influence of various xuv pulse parameters, e.g. pulse durations. The experimentally observed delay dependence of the double ionization is well reproduced in our simulations.

[1] F. Krausz and M. Ivanov, Rev. Mod. Phys. 81, 163 (2009); [2] M. Uiberacker et al., Nature (London) 446, 627 (2007)

A 8.25 Tu 16:30 Lichthof

First Experiments on Quantum Dynamics with Attosecond Pulses in a Reaction Microscope — •Helga Rietz, Ram Gopal, Alexander Sperl, Konstantinos Simeonidis, and Joachim Ullrich — Max-Planck-Institut für Kernpyhsik, Heidelberg

We present the first measurements taken with the reaction microscope that has recently been installed at the attosecond beamline at Max-Planck-Institut für Kernpyhsik, Heidelberg. Combining a versatile HHG-source with a compact reaction microscope, this setup has been designed for the investigation of the electronic response in atoms and molecules.

As a first test of the assembly, we observed sidebands in electron spectra from He- and Ar-ionization that confirm the interferometric stability of the setup. These features were also used to confirm the duration of the applied IR-laser pulses. The following experiments in D_2, which were carried out with laser pulses of approximately 30 fs duration, showed a clear signature of bond softening [1] in presence of the IR-field. Changing to laser pulses that were further shortened down to about 8 fs by spectral broadening in an optical fiber and a subsequent chirped mirror compressor, we observed oscillations of the vibrational nuclear wavepacket in D_2^+ (see Ergler et al. [2]). The successful reproduction of these features explored earlier by other researchers now allows us to move on to new experiments.

[1] P. H. Bucksbaum et al., *Phys. Rev. Lett.* **64**, 1990
[2] Th. Ergler et al., *Phys. Rev. Lett.* **97**, 2006

A 8.26 Tu 16:30 Lichthof

Design and Setup of a Broadband Collinear Attosecond Beamline — •Michael Schönwald, Christian Ott, Philipp Raith, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

We present the design of a new attosecond beamline which is currently being set up in our laboratory. Using 6-fs duration CEP-stabilized ultrashort laser pulses, high-harmonic radiation is generated in a cell filled with rare gases (typically Ar, Ne). The time delay (between the XUV and IR) is realized by a plane split mirror hit at gracing incidence. Another toroidal mirror is then used to refocus both the harmonic and the IR light onto a gas target in a 1:1 focusing geometry. With this novel experimental design we expect the advantage of the high interferometric stability of a monolithic scheme where both beams propagate exactly into the same direction. Furthermore, as we are only using gracing-incidence reflections off metal mirrors for refocusing of the EUV harmonics, we avoid bandwidth limitations associated with the normal incidence on a multilayer mirror. The beamline thus flexibly adapts to any harmonic photon-energy range obtained with different generation media. It also supports tunable and broad-band/ultrashort attosecond pulses by the application of gating techniques. Both design and construction stages of the setup will be shown, including simulations and first experiments on the characterization of the new source. As an outlook, possible future experiments will be briefly discussed, mainly focusing on interferometric approaches [1].

1. Pfeifer *et al.*, Chem. Phys. Lett. 463, 11-24 (2008)

A 8.27 Tu 16:30 Lichthof

Analysis of the recombination step in high-order harmonic generation — •Elmar Vincent van der Zwan[1,2], Maria Tudorovskaya[1,2], and Manfred Lein[1] — [1]Centre for Quantum Engineering and Space-Time Research (QUEST) and Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany — [2]Institut für Physik, Universität Kassel, Heinrich-Plett-Str. 40, 31432 Kassel, Germany

Although single-active-electron harmonic spectra can be calculated routinely, both using the time-dependent Schrödinger equation and trajectory-based approaches, they still contain many unexplored aspects that have implications for molecular imaging. We study the question to what extent the recombination step in high-order harmonic generation is described by the laser-field-free continuum-bound transition amplitude. For different alignment angles of the molecule we study the harmonics generated from H_2^+ by linearly polarized laser pulses of both physical and artificial types. This is compared to harmonics from field-free collisions with Gaussian electron wave packets. We thus disentangle the influence of the Coulombic potential and the laser field on the two-center interference. The results provide information on the recombining electronic wave packet that can be used in imaging techniques, such as molecular orbital tomography. We find significant ellipticity in the polarization of the harmonics. Furthermore, we study the role of resonance states in harmonic generation, aiming at verifying the common belief that the time scales in high-order harmonic generation are too short for sharp resonances to develop fully.

A 8.28 Tu 16:30 Lichthof

Optimization of the charge state distribution in an electron beam ion trap using dielectronic recombination — •Sven Bernitt, Rainer Ginzel, Lodewijk Arntzen, José R. Crespo López-Urrutia, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

When an energetic electron recombines with an ion, an inner-shell electron of the ion can be resonantly excited. The resulting excited state can decay radiatively, leaving the ion with its charge decreased by one (dielectronic recombination, DR). Due to large cross sections compared to non-resonant radiative recombination, DR has an substantial effect on the recombination rates in hot plasmas and thus on the charge state distribution. This can be systematically influenced due to the resonant nature of DR. To investigate this possibility highly charged krypton ions were extracted from the Heidelberg Electron Beam Ion Trap (HD-EBIT), separated into their charge states and counted as a function of the electron energy. Yield increases were observed in single charge states by factors larger than three, while other charge states were suppressed. These results further improve the unique ability of electron beam ion traps to generate ion beams in a very narrow charge state distribution, a highly desirable feature for example for studies of rare isotope ion beams.

A 8.29 Tu 16:30 Lichthof

Electron impact ionization of small rare gas clusters — •Thomas Pflüger, Arne Senftleben, Xueguang Ren, Alexander Dorn, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

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. Especially small argon clusters have been extensively studied for decades, however, coincidence experiments are rare. We performed kinematically complete electron impact ionization experiments were all final state particles were measured and differential cross sections could be obtained. Besides direct single ionization the results show a second distinct reaction channel which can be accounted for an additional inelastic scattering event inside the cluster. Furthermore, compared to the results for atomic argon, strongly increased intensities outside of the scattering plane, which is spanned by the incident and scattered projectile, are observed.

A 8.30 Tu 16:30 Lichthof

High precision wavelength measurements of X-ray Li- and Be-like Fe satellite lines — •Katharina Kubiček, José R. Crespo López-Urrutia, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

We report on high precision wavelength measurements of dielectronic satellite lines in Li- and Be-like iron excited through resonant electron capture by the monoenergetic electron beam of the FLASH-EBIT. A advanced flat crystal x-ray spectrometer was used while stepwise varying the beam energy. Whereas conventional experiments on dielectronic recombination focus on high electron beam energy resolution, and provide only poor photon energy resolving powers of about $E/\Delta E = 50$, in this configuration transition energies are measured with a value $E/\Delta E = 2000$ by determining absolute Bragg angles without the need of reference lines. Estimated experimental uncertainties of $\Delta E < 18$ meV allow to probe QED contributions of some few eV to transition energies with high sensitivity.

A 8.31 Tu 16:30 Lichthof

Resonant electron-ion photorecombination processes of higher order — •Christian Beilmann[1], Octavian Postavaru[1], Lodewijk Arntzen[1], Rainer Ginzel[1], Christoph H. Keitel[1], Volkhard Mäckel[1], Paul H. Mokler[1], Martin C. Simon[1], Hiro Tawara[1], Joachim Ullrich[1], José R. Crespo López-Urrutia[1], and Zoltán Harman[1,2] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]ExtreMe Matter Institute (EMMI), Darmstadt, Germany

Dielectronic recombination (DR), the fundamental process where a free electron is captured by the potential of a highly charged ion and its kinetic energy is transfered to a bound electron, has been intensively investigated due to its interest for fundamental atomic physics and the diagnostic of astrophysical and earthbound plasmas. Besides DR, there are resonant photorecombination processes of higher order. In these, two or three bound electrons can be simultaneously excited by the captured electron in the so-called trielectronic (TR) or quadruelectronic (QR) recombination. Measurements of TR are very scarce and the first observations of TR involved only low energy excitation of the L-shell. We present the first observation of TR with K-shell excitation as well as signatures of QR obtained by high electron energy resolution recombination measurements in an electron beam ion trap (EBIT) [1]. Investigations of Ar, Fe and Kr allow for Z dependency studies of TR cross sections, and show large, and even dominant contributions of this process to the total resonant photorecombination cross section.

[1] C. Beilmann, O. Postavaru, et al., PRA 80, 050702(R) (2009)

A 8.32 Tu 16:30 Lichthof

Fabrication and characterization of carbon nantubes structures on atom chipsvi — •Gabriela Visanescu, Peter Federsel, Michael Häffner, Philipp Schneeweiss, Michael Gierling, Dieter Kern, Andreas Günther, and Jozsef Fortágh — Center for Collective Quantum Phenomena and their Applications, Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen http://www.pit.physik.uni-tuebingen.de/fortagh/

Carbon nanotubes have been grown using plasma enhanced chemical vapour deposition (PECVD) on the surface of a silicon substrate. Free standing multiwall nanotubes, lines of nanotubes, carpets of nanotubes, and suspended beams of single wall nanotubes have been fabricated. We characterize the structure and mechanical properties of the nanotubes by means of scanning electron microscopy (SEM) and an atomic force microscopy (AFM). We observe that the mechanical resonance frequency of the fabricated nanotubes (4-20um length) is in the range between tens of MHz and a few hundred kHz. The chips with carbon nanotubes find application in cold atom experiments as potential generating elements and in atom detectors based on field ionization near nanotube tips and subsequent ion counting.

A 8.33 Tu 16:30 Lichthof

Solar Wind Interacting with Comets: X-ray emission following charge exchange — •Rainer Ginzel, Stuart Higgins, Sven Bernitt, José R. Crespo López-Urrutia, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Collisions of highly charged ions and neutrals resulting in X-ray emission are observed in cometary and planetary atmospheres [1] and also in supernova ejecta. Much of the necessary data to model these environments are unavailable and some of the existing data are even contradictory [2]. To overcome this unsatisfactory situation we have developed a novel deceleration platform at the Heidelberg Electron Beam Ion Trap (EBIT) which provides a slow, monoenergetic, and well-focused ion beam, allowing ion-atom collisions at energies between 10 keV/q and 30 eV/q to be studied in depth, featuring the possibility of ion-photon coincidence measurements.

First experiments with highly charged argon and sulfur ions were performed at energies between 100 and 600 eV/amu, an energy range relevant for modeling the slow components of the solar wind. These measurements have shown the importance of the formation of long lived metastable states. The X-ray emission caused by their decay could be separated and measured independently. The aforementioned contradictions in existing data could potentially be resolved through the reinterpretation of datasets, in light of these new findings.

[1] P. Beiersdorfer *et al.*, *Science* **300**, 1558 (2003)
[2] F. I. Allen *et al.*, *Physical Review* **A78**, 032705 (2008)

A 8.34 Tu 16:30 Lichthof

Interaction of swift heavy- ion beams with insulating targets — G Lanzanó[1], E De Filippo[1], I Lombardo[1], E La Guidara[1], F Amorini[1], N Rizzo[1], G Politi[1], E Geraci[1], P Russotto[1], G Cardella[1], C Volant[2], H Rothard[3], and •S Hagmann[4,5] — [1]INFN+LNS, Catania, Italy — [2]CEA, Saclay, France — [3]CIMAP-CIRIL-GANIL,Caen, France — [4]GSI-Darmstadt, Germany — [5]Inst.f Kernphysik, Univ Frankfurt, Germany

The interaction of ion beams with solids leads to ejection of electrons. For insulating targets, a charging-up of the surface occurs. At present,such phenomena are under inves-tigation in connection with guiding phenomena in nano-cap-illaries with the possible application of nano focused beams. Here, we report the results of a series of dedicated experiments with swift ion beams (C at 23 and 40 AMeV, but also heavier beams such as Ag at 40 A MeV and Xe at 23 and 30 AMeV) and insulating foil targets (Mylar,polypropylene). Also, sandwich-targets (insulators covered with a thin gold layer on one or both surfaces)were used. Fast electron spectra were measured by the time-of-flight method with the ARGOS multidetector at the superconducting cyclotron of LNS Catania. The slowing down of convoy- and binary encounter electrons allows to observe the dynamics of charge build-up leading to potentials of the order of 10 kV [1]. Surprisingly, also X-rays emitted from the projectile are affected by the charged surface, and puzzling results are observed with the double sandwich target. [1] G. Lanzanò, E. De Filippo, S. Hagmann, H. Rothard, C. Volant Rad. Eff. and Defects in Solids 162 (2007) 303-318

A 8.35 Tu 16:30 Lichthof

Fully differential measurements for electron capture in collisions of slow He^{q+} and Ne^{q+} with He and Ne. — •Aditya H. Kelkar, Xincheng Wang, Daniel Fischer, Robert Moshammer, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

We report on kinematically complete studies of electron capture from He (and Ne) in collisions with slow He^{q+} (and Ne^{q+}) projectiles using a 'Reaction Microscope'. We succeeded in collecting fully differential data sets for several reaction channels like single and double electron capture, resonant capture and capture accompanied with subsequent auto-ionization. The results are compared with theoretical model calculations. In order to achieve an efficient detection of emitted recoilions and electrons we implemented large area position sensitive MCP detectors with central holes for the passage of the projectile beam. This enabled us to measure the recoiling target ion in coincidence with Auger-electrons emitted from the highly excited projectile ion after capture. The experimental setup and first results of ongoing measurements will be presented.

A 8.36 Tu 16:30 Lichthof

First results from 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 Hagman[5], Aditya Kelkar[1,2], Tom Kirchner[6], Kai-Uwe Kühnel[1], Xincheng Wang[1], 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]Institute of High Performance Computing, Singapore — [5]GSI, Darmstadt, Germany — [6]York University, Toronto, Canada

A Reaction Microscope, which enables fully momentum resolved measurements of ionization and charge transfer processes in ion-atom collisions, is implemented in the ion storage ring TSR at the MPIK. Due to the low beam emittance and high intensity achievable in the TSR, the collision dynamics can be studied with high statistics and very good resolution, even on the level of fully differential cross sections. In first measurements, double ionization of helium was studied over a wide range of perturbation parameters η (projectile charge to velocity ratio) and analyzed by means of so-called four-particle Dalitz plots. It is shown that for large η, as expected, the data can best be described by a process not involving the electron-electron correlation. In an upcoming beamtime we aim at kinematically complete measurements for radiative electron capture (REC) in ion-atom collisions, the dominant process for electron transfer at high collision velocities.

A 8.37 Tu 16:30 Lichthof

Characterization of the liquid droplet target beam at the ESR — •Nikolaos Petridis[1], Thomas Stoehlker[2], and Robert E. Grisenti[1] — [1]Institut fuer Kernphysik, JWG-Universität Frankfurt, Germany — [2]GSI, Darmstadt, Germany

At storage rings, atomic processes with small cross-sections (e.g. excitation) can only be studied efficiently when high-density targets are available, in spite of the fact that the ions collide several million times per second with the target. Even state-of-the-art internal targets, which are usually realized by expanding a gas through a nozzle into vacuum, provide target gas densities that are generally still too low. For many nuclear and atomic physics experiments, such as those planned at future facilities like FAIR, this is still a problem. Recently, we have successfully employed a novel cryogenically cooled liquid droplet beam source, and demonstrated that target densities of at least one order of magnitude higher, as compared to previous internal targets, are now experimentally feasible. In order to fully characterize the liquid target beam, we have carried out extensive investigations on ion beam heating and losses during the interaction of the droplets with relativistic hydrogen- and lithium-like uranium ions. Here, we will present the experimental data that are presently being analyzed, and discuss the possible use of droplets for the investigation of fully unexplored collision phenomena. For, the interaction of relativistic highly-charged heavy ions with droplets can, in some respect, be compared to that of intense ultra-short laser-cluster interactions.

A 8.38 Tu 16:30 Lichthof

X-ray spectroscopy of collisions between highly charged Ru ions and H_2 clusters — T. Aumann[1], S. Bishop[3], K. Blaum[9], K. Boretzky[1], F. Bosch[1], H. Bräuning[1], C. Brandau[1,3], T. Davinson[4], I. Dillmann[3], O. Ershova[1,5], H. Geissel[1], G. Gyürky[6], M. Heil[1], F. Käppeler[7], A. Kelic-Heil[1], C. Kozhuharov[1], C. Langer[1,5], T. Le Bleis[1,5,10], Y.A. Litvinov[1,9], G. Lotay[3], J. Marganiec[1], N. Petridis[5], R. Plag[1,5], U. Popp[1], R. Reifarth[1,5], B. Riese[1], C. Rigollet[8], C. Scheidenberger[1], H. Simon[1], Th. Stöhlker[1,11], T. Szücs[6], G. Weber[1,11], H. Weick[1], D.F.A. Winters[1,11], •N. Winters[1,11], P.J. Woods[4], and Q. Zhong[1,2] — [1]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany — [2]China Institute of Atomic Energy (CIAE), 102413 Beijing, China — [3]Technische Universität München, 85748 Garching, Germany — [4]University of Edinburgh, EH8 9YL Edinburgh, United Kingdom — [5]Goethe-Universität, 60438 Frankfurt a.M, Germany — [6]Institute of Nuclear Research of the Hungarian Academy of Sciences, H-4001 Debrecen, Hungary — [7]Forschungszentrum Karlsruhe, Institut für Kernphysik, 76131 Karlsruhe, Germany — [8]Kernfysisch Versneller Instituut, 9747 AA Groningen, The Netherlands — [9]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [10]Institut Pluridisciplinaire Hubert Curien, 67037 Strasbourg, France — [11]Ruprecht-Karls-Universität, 69120 Heidelberg, Germany

We performed x-ray spectroscopy of collisions between Ru^{44+} and H_2 clusters at low energies (≈10 MeV/u) at the Experimental Storage Ring in Darmstadt. This study was performed together with the main experiment, which looked at proton capture (from H_2 by the ion) during the collision (*p*-process). Our goal was to identify the influence of the target density (cluster size) on the collisions via the recorded x-ray spectra. The clusters were generated by a novel cryogenic cluster source, which can create clusters with area-densities as high as 10^{13} 1/cm^2. We will present the results of our analysis and discuss a follow-up experiment.

A 8.39 Tu 16:30 Lichthof

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

The diffraction of electrons by a standing light wave is referred to as the Kapitza-Dirac effect, which has been observed in recent experiments [1, 2] at moderate laser intensities. Current high-power lasers have relativistic intensities in the optical regime and reach short wave lengths in the X-ray range, which opens the possibility to study the Kapitza-Dirac effect in regimes, where relativistic effects become important.

The non-relativistic Kapitza-Dirac effect was studied theoretically in [3] by solving the Schrödinger equation by a plane wave ansatz, which yields the time-evolution of the electron momentum distribution. In our work, we generalize this approach and apply it to the Dirac equation. We will highlight differences between the relativistic and the non-relativistic description of the Kapitza-Dirac effect.

[1] Daniel L. Freimund, Kayvan Aflatooni, Herman Batelaan, Nature **413**, 142–143 (2001)
[2] P. H. Bucksbaum, D. W. Schumacher, M. Bashkansky, Phys. Rev. Lett. **61**, 1182–1185 (1988)
[3] H. Batelaan, Rev. Mod. Phys. **79**, 929–941 (2007)

A 8.40 Tu 16:30 Lichthof

Erzeugung hoher harmonischer Strahlung in dichten Medien — •Heiko G. Kurz[1,2], Tobias Vockerodt[1,2], Hendrik Thering[1], Uwe Morgner[1,2,3] und Milutin Kovacev[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]QUEST — [3]Laserzentrum Hannover e.V.

Die Erzeugung kohärenter Strahlung im vakuum-ultravioletten und extrem-ultravioletten Spektralbereich ist Gegenstand der aktuellen Forschung moderner Quantenoptik. Die Erzeugung hoher harmonischer Strahlung (HHG) erfolgt in einer nichtlinearen Frequenzkonversion intensiver Laserpulse in Gasen, Festkörpern oder Flüssigkeiten. Die verschiedenen Targets unterscheiden sich hinsichtlich ihrer Konversionseffizienz, wobei mit steigender Dichte des Targets eine Erhöhung der Effizienz beobachtet werden kann. In diesem Beitrag wird ein Experiment zur HHG in Flüssigkeitstropfen vorgestellt, welches die debrisfreie Konversion der Strahlung mit einer hohen Dichte des Targets verbindet. Aktuelle Ergebnisse werden präsentiert.

A 8.41 Tu 16:30 Lichthof

Crossed-beam laser acceleration of ions by high-intensity laser fields — •Benjamin Galow, Zoltán Harman, Dunfu Shi, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69029 Heidelberg, Germany

Simulations based on the coupled relativistic equations of motion show that an ensemble of ions stemming from laser-plasma acceleration processes can be post-accelerated using crossed pulsed laser beams focused to spot radii on the order of the laser wavelength. We demonstrate that the crossed beams produce monoenergetic accelerated particles of several hundred MeV/nucleon with small energy spreads and high densities as required for hadron cancer therapy.

A 8.42 Tu 16:30 Lichthof

Electron Dynamics of F_2^- in a Strong Laser Field. — •Hannes Hultgren and Igor Kiyan — Albert-Ludwig University, Faculty of Mathematics and Physics, D-79104 Freiburg, Germany

F^- and F_2^- are exposed to a strong, infrared laser pulse of linear polarization. An electron imaging spectrometer operated in the velocity mapping regime is used to record angular resolved photoelectron spectra. Both F^- and F_2^- spectra are recorded during the same run of experiment. The spectra exhibit a non-monotonic structure, which is associated with the quantum interference effect predicted by a Keldysh-like theory [1]. The character of this structure is similar in both spectra and it corresponds to detachment of an initially bound *p*-electron. However, the energy distribution of F_2^- extends to higher kinetic energies than the energy distribution of F^-.

Two different models are considered for the data interpretation. One of these assumes photodissociation of F_2^- at the leading front of the laser pulse, followed by photodetachment of F^- created in the photodissociation step. Another model involves simulations based on the theory presented in [2], which uses the molecular strong-field approximation.

[1] G.F Gribakin and M.Yu. Kuchiev, Phys. Rev. A, **55**, 3760 (1997).
[2] D.B. Milošević, Phys. Rev. A, **74**, 063404 (2006)

A 8.43 Tu 16:30 Lichthof

An efficient numerical propagation scheme for the Klein-Gordon equation — •Matthias Ruf, Heiko Bauke, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The Klein-Gordon equation [1] is a Lorentz invariant equation of motion for spinless particles. We present a real space split operator method [2] for the solution of the time-dependent Klein-Gordon equation with arbitrary electromagnetic fields. Split operator methods for the Schrödinger equation and the Dirac equation typically operate alternately in real space and momentum space and, therefore, require the computation of a Fourier transform in each time step. However, the fact that the kinetic energy operator $\hat{K}$ in the two-component representation of the Klein-Gordon equation is a nilpotent operator, that is $\hat{K}^2 = 0$, allows us to implement the split operator method for the Klein-Gordon equation entirely in real space.

Consequently, the proposed split operator method does not require the computation of a Fourier transform. We implemented a highly parallel computer program for the propagation of the Klein-Gordon equation. Parallelization is based on domain decomposition. Our poster will outline the real space split operator method and will present applications as well as performance measurements.

[1] H. Feshbach and F. Villars, Rev. Mod. Phys. **30**, 24–45 (1958)
[2] Matthias Ruf, Heiko Bauke and Christoph H. Keitel, J. Comp. Phys. **228**, 9092–9106 (2009)

A 8.44 Tu 16:30 Lichthof

Velocity Map Imaging of Xe Clusters Irradiated with FEL Raditation — •Sebastian Schorb[1], Rainer Unterumsberger[1], Daniela Rupp[1], Tais Gorkhover[1], Benjamin Röben[1], Tobias Zimmermann[1], Thomas Möller[1], Per Johnsson[2], Marc Vrakking[3], and Christoph Bostedt[4] — [1]Institut für Optik und Atomare Physik, Technische Universität Berlin — [2]Department of Physics, Lund University — [3]FOM Institut AMOLF — [4]Linac Coherent Light Source, SLAC

For many potential experiments with free electron lasers it is of fundamental importance to study how the absorption and ionization properties of nanoscaled systems develop in the short wavelength – strong field domain. We performed first single-shot ion velocity map imaging (VMI) experiments on Xe clusters at the FLASH FEL at DESY in Hamburg. The Xe was resonantly excited at the 4d core level with power densities up to 1014 W/cm2. A special velocity map imaging spectrometer configuration was used to detect charged fragments with kinetic energies up to 600 eV per charge. By pulsing the detector, the kinetic energy distribution of different species and charge states could be investigated separately. With a piezo driven skimmer the density of the cluster beam could be reduced to a single cluster in the focal volume. The images show an isotropic spatial ion distribution and kinetic energy distribution changing with the charge state. This could be interpreted as an indication for a shell by shell explosion of the clusters. The data is discussed and compared to theoretical predictions and experimental results.

A 8.45 Tu 16:30 Lichthof

Effects of the carrier-envelope phase of few-cycle laser pulses on atomic bound states — •Fabian Elster[1,2], Anne Harth[1,2], Stefan Rausch[1,2], Thomas Binhammer[1,2], Mathias Hoffmann[1,2], and Uwe Morgner[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Hannover, Germany — [2]Quest: Center for Quantum Engineering and Space-Time Research, Hannover, Germany

We present a setup to study effects of the carrier envelope phase (CEP) of a sub-5-fs pulse from a phase stabilized Ti:sapphire laser oscillator with pulse energies in the nJ regime by spectroscopic observation of the excited atomic gas target to obtain the population of an atomic bound state. Theoretical work indicates a small dependence of the population on the CEP of the exciting pulse. We analyze the qualification of different atomic systems (alkaline and alkaline earths) with respect to the expected overall signal strength with a comprehensive theoretical model. On this basis, we discuss the details of the experimental setup.

A 8.46 Tu 16:30 Lichthof

Coulomb effects on low-energy momentum spectra in strong field ionization — •Tian-Min Yan[1] and Dieter Bauer[2] — [1]Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg, Germany — [2]Institut für Physik, Universität Rostock, 18051 Rostock, Germany

For low-energetic photoelectrons emitted from Coulombic binding potentials, the momentum spectra as they are predicted by the plain "strong field approximation" (SFA, see [1] for a review) are in strong qualitative disagreement with ab initio results and experiment. Recently, a surprising "low energy structure" (LES) has been identified in experiments using long wavelengths [2]. We present results from the numerical solution of the time-dependent Schrödinger equation and compare them to Coulomb-corrected SFAs. Plain SFA and some of the Coulomb-corrected SFAs do not reproduce the low-energy nodal pattern in the momentum spectra, while others do. The origin of the LES at long wavelengths is also discussed.

[1] D.B. Milosevic et al., J. Phys. B 39, R203 (2006).
[2] C.I. Blaga et al., Nature Phys. 5, 335 (2009).

A 8.47 Tu 16:30 Lichthof

Stabilization dynamics of a model hydrogen molecular ion: Floquet and time-dependent density functional theory analysis — •Varun Kapoor[1] and Dieter Bauer[2] — [1]Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg, Germany — [2]Institut für Physik, Universität Rostock, 18051 Rostock, Germany

Atomic and molecular systems put into strong high-frequency radiation are known to stabilize against ionization. In the molecular case the question arises how the dissociation dynamics is influenced by the stabilized electron. We solve the time-dependent Schrödinger equation for a model hydrogen molecular ion. The observed dynamics and the harmonics emitted are analyzed in terms of Floquet states. In general, several of the eigenstates of the combined electron-ion Kramers-Henneberger potential are occupied. The exact results are compared with results from a multi-component time-dependent density functional theoretical treatment of the system, evaluating different levels of approximation to the exchange correlation potential.

A 8.48 Tu 16:30 Lichthof

Strong-field ionization of N_2, O_2, and CO_2 — •Simon Petretti[1], Yulian Vanne[1], Alejandro Saenz[1], Alberto Castro[2], and Piero Decleva[3] — [1]Humboldt-Universität zu Berlin, Germany — [2]Freie Universität Berlin, Germany — [3]Universitá di Trieste, Italy

The availability of intense laser pulses with ultrashort pulse durations in the range of a few femtoseconds (or even attoseconds) offers a new way of exploring the behavior of molecules interacting with these intense laser fields. The femtosecond timescale should, e. g., be appropriate for time-resolved imaging of chemical reactions. Experimental progress towards this goal has been made by resolving molecular orbitals [1]. In order to check the assumption that molecular orbitals can be really imaged, we have set up a new theoretical model. The multiphoton ionization of molecules in intense laser fields is studied within the so-called single-active electron (SAE) approximation by solving the time-dependent Schrödinger equation (TDSE) numerically. Our code is designed in such a way that it can deal with in principle arbitrary molecules. The main focus of this presentation will be the alignment-dependent strong-field ionization of N_2, O_2, and CO_2 exposed to a short laser pulse (40 fs pulse duration) of a Ti:sapphire laser (800 nm) as recently investigated experimentally [2]. We do not only achieve qualitative agreement for N_2 and O_2, but provide also an explanation for the so far puzzling experimental CO_2 results.

[1] Itatani *et al.*, Nature **432**, 867 (2004).
[2] Pavičić *et al.*, Phys. Rev. Lett. **98**, 243001 (2007).

A 8.49 Tu 16:30 Lichthof

A Fraunhofer diffraction model of non-collinear high harmonic generation — •Andreas Vernaleken, Akira Ozawa, Igor Gotlibovych, Thomas Udem, and Theodor W. Hänsch — Max-Planck-Institut für Quantenoptik, Garching

Non-collinear high harmonic generation (NCHHG) is the nonlinear process where two infrared driving beams focused into a gas target at a small angle cause collimated emission of high harmonic radiation along the bisector of the driving beams [1]. Most of the striking features of NCHHG that we observed in our experiments can now be reproduced by our improved numerical simulation. The simulation results suggest that NCHHG can be seen as the Fraunhofer diffraction pattern of the high harmonic emission profile in the interaction region that is created by interference between the two driving beams.

A sound understanding of the physics of NCHHG is crucial considering its potential as a combined method for efficient generation and outcoupling of extreme ultraviolet radiation in future cavity-assisted HHG experiments at high power and high repetition rate. We will present the relevant details of our model and its current limitations and discuss possible future applications of NCHHG.

[1] Ozawa et al., Opt. Express **16**, 6233 (2008)

A 8.50 Tu 16:30 Lichthof

Visualizing the vibrational motion of D_2 by XUV-Pump/XUV-Probe experiments at FLASH — •Yuhai Jiang[1], Artem Rudenko[2], Etienne Plésiat[3], Lutz Foucar[2], Moritz Kurka[1], Kai-Uwe Kühnel[1], Jhon Pérez[3], Fernando Martin[3], Oliver Herrwerth[4], Matthias Lezius[4], Matthias Kling[4], Till Jahnke[5], Ali Belkacem[6], Michael Schulz[7], Kiyoshi Ueda[8], Theo Zouros[9], Stefan Düsterer[10], Rolf Treusch[10], Claus Dieter Schröter[1], Robert Moshammer[1], and Joachim Ullrich[1] — [1]MPIK, 69117 Heidelberg — [2]ASG at CFEL, 22607 Hamburg — [3]Universidad Autónoma de Madrid, 28049 Madrid — [4]MPIQ, 85748 Garching — [5]Universität Frankfurt, 60486 Frankfurt — [6]LBNL, 94720 Berkeley — [7]University of Missouri-Rolla, 65409 Rolla — [8]Tohoku University, 980-8577 Sendai — [9]University of Crete, 71003 Heraklion, Crete — [10]DESY, 22607 Hamburg

Two-photon double ionization (TPDI) of D_2 is studied for 38 eV photons at FLASH as function of the time delay between the two photoabsorption events using a XUV-pump/XUV-probe setup in combination with a reaction microscope. Instantaneous and sequential absorption pathways are identified as separated peaks in the measured D^++D^+ fragment kinetic energy release spectra. Sequential TPDI exhibits clear pump-probe delay time dependent structures originating from the ultrafast nuclear wave-packet motion in D_2^+ ($1s\sigma_g$-state). Time-dependent model calculations support this interpretation and are in agreement with the experimentally observed vibrational period of 22±4 fs (D_2^+).

A 8.51 Tu 16:30 Lichthof

Isomerisation of Acetylene followed in Real-Time by Pump-Probe experiments at FLASH — •Yuhai Jiang[1], Artem Rudenko[2], Lutz Foucar[2], Moritz Kurka[1], Kai-Uwe Kühnel[1], Oliver Herrwerth[3], Matthias Lezius[3], Matthias Kling[3], Till Jahnke[4], Ali Belkacem[5], Michael Schulz[6], Kiyoshi Ueda[7], Theo Zouros[8], Stefan Düsterer[9], Rolf Treusch[9], Claus Dieter Schröter[1], Robert Moshammer[1], and Joachim Ullrich[1] — [1]MPIK, 69117 Heidelberg — [2]ASG at CFEL, 22607 Hamburg — [3]MPIQ, 85748 Garching — [4]Universität Frankfurt, 60486 Frankfurt — [5]LBNL, 94720 Berkeley — [6]University of Missouri-Rolla, 65409 Rolla — [7]Tohoku University, 980-8577 Sendai — [8]University of Crete, 71003 Heraklion, Crete — [9]DESY, 22607 Hamburg

Isomerisation is an elementary chemical reaction where the conformation of a molecule evolves continuously through a sequence of transient species that are neither reactants nor products, but finally turning the former into the latter. Using a XUV-Pump/XUV-Probe setup in combination with a reaction microscope we were able to visualize the isomerisation of acetylene cations ($HC{=}CH^+$) that were created by ionization of neutral molecules in the gas phase during the pump pulse (38 eV photon energy). This has been achieved by analyzing the C^++CH^{2+} fragmentation channel, which serves as an indicator for the transfer of a proton from one end of the molecule to the other end, as function of the pump-probe delay time. We obtained a mean isomerization time of about 50 fs.

A 8.52 Tu 16:30 Lichthof

Erzeugung hochenergetischer 88 nm XUV-Laserpulse mit fs Pulsdauer — •Hendrik Thering[1,2], Tobias Vockerodt[1,2], Heiko Kurz[1,2], Emilia Schulz[1,2], Daniel S. Steingrube[1,2], Uwe Morgner[1,2,3] und Milutin Kovacev[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]QUEST Centre for Quantum Engineering and Space-Time Research — [3]Laser Zentrum Hannover e.V.

Wir stellen einen Ansatz vor, der die Erzeugung von Millijoule XUV-Laserpulsen mit Femtosekunden Pulsdauern in Aussicht stellt. Dies soll durch die mehrfache Erzeugung niedriger Harmonischer realisiert werden. Mittels SHG und SFG wird Ti:Sa-Strahlung (792 nm, 300 mJ, 100 fs) ins ferne UV konvertiert (264 nm, 36 mJ). Bei der anschließenden Frequenzverdreifachung in Argon streben wir Effizienzen von 1,5% an (Appl. Phys. B 75, 629 (2002)). Somit ergäben sich Pulsenergien von 0,5 mJ bei einer Wellenlänge von 88nm. Die resultierende Gesamtkonversionseffizienz läge bei 0,3% und somit ein bis zwei Größenordnungen über der für HHG typischen Konversionseffizienz.

A 8.53 Tu 16:30 Lichthof

Pion pair creation in ultrarelativistic proton-laser collisions — •Anis Dadi and Carsten Müller — Max-Planck-Institut für Kernphysik, Heidelberg

The production of charged pion pairs via few-photon absorption from an intense, circularly polarized X-ray laser wave colliding with an ultrarelativistic proton beam is studied. Our calculations include the contributions from both the electromagnetic and hadronic interactions. They moreover account for the finite size of the projectile and the composite nature of the created particles.

The pion production rates are compared with the corresponding ones for muon pairs. We also give a general discussion of similarities and differences between the pair creation of Bose versus Dirac particles.

A 8.54 Tu 16:30 Lichthof

The relevance of recoil effects in electron-positron pair creation by relativistic particle impact on intense laser fields — •Sarah Müller, Huayu Hu, and Carsten Müller — Max-Planck-Institut für Kernphysik, Heidelberg

Recoil effects in the process of pair creation by a relativistic particle beam colliding with an intense laser wave are studied. Within the framework of laser-dressed quantum electrodynamics, we evaluate to this end the Feynman diagram for multiphoton pair production by muon impact on a high–frequency laser beam of circular polarization. This allows us to calculate the recoil distribution of the projectile and to analyze its dependences on the particle mass and the number of absorbed laser photons. We also discuss the correlation between the emission angles of the produced pair.

[1] S. Müller and C. Müller, Phys. Rev. D 80, 053014 (2009)

A 8.55 Tu 16:30 Lichthof

Auger processes in multielectron ionization of xenon atoms induced by intense XUV laser pulse — •Myroslav Zapukhlyak, Roland Guichard, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden, Germany

Recent experiments at FLASH show that the intense XUV laser pulse can produce Xe ions with up to 21+ charge state [1]. At a photon frequency of 93 eV autoionization processes significantly affect the ionization and make a theoretical description very challenging. Ab-initio TDDFT calculations were performed for the time propagation of the system. In order to obtain q-fold ionization probabilities and to include the effect of autoionization we adopt a statistical model which was developed for the description of multielectron ionization in ion-atom collisions [2]. Our calculations show that this model is able to reproduce qualitatively the prominent features of the experimental data. Taking into account the experimental uncertainties of the laser pulse profile is necessary to get a quantitative agreement between the theoretical and experimental values.

[1] A. Sorokin et al., Phys. Rev. Lett. 99, 213002 (2007)
[2] T. Spranger and T. Kirchner, J. Phys. B 37, 4159 (2004)

A 8.56 Tu 16:30 Lichthof

Bound Dirac electrons interacting with laser fields — •Octavian Postavaru[1,2], Zoltán Harman[1,2], and Christoph H. Keitel[1] — [1]Max-Plank-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]ExtreMe Matter Institute EMMI, Planckstrasse 1, 64291 Darmstadt, Germany

We investigate the level structure and excitation processes of few-electron ions in laser beams. Interaction with the light field leads to dynamic shifts and splitting of the electronic energy levels. We apply a fully relativistic description of the electronic states by means of the Dirac equation. The frequency spectrum of the fluorescence photons for resonant driving, as well as excitation rates and light shifts in the case of two-photon excitation are presented. The results are relevant for experiments at present and near-future laser facilities.

A 9: Ultra-Cold Atoms, Ions and BEC II (with Q)

Time: Wednesday 10:30–12:30 Location: F 303

A 9.1 We 10:30 F 303

Creating versatile atom traps by combining laser light and magnetic fields — •Stephan Middelkamp[1], Michael Mayle[1], Igor Lesanovsky[2], and Peter Schmelcher[1] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Hamburg, Germany — [2]School of Physics and Astronomy, Faculty of Science, University of Nottingham, Nottingham, UK

We utilize the combination of two standard trapping techniques, a magnetic trap and an optical trap in a Raman setup, to propose a new versatile and tunable trap for cold atoms. The thus created potential has got several advantages compared to conventional trapping potentials: One can easily convert the type of the trap, e.g. from a single well to a double well trap. One can trap atoms in different internal states in different trap types enabling the realization of new experiments with multi-component Bose-Einstein condensates. One can achieve variations of the trapping potential on small length scales ($\sim \mu$m) without the need for microstructures. We present the potential surfaces for different setups, show their tunability, give a semi-analytical expression for the potential, and propose experiments which can be realized within such a trap.

A 9.2 We 10:45 F 303

Few-boson tunneling in a double well with spatially modulated interaction. — •Budhaditya Chatterjee[1], Ioannis Brouzos[2], Sascha Zöllner[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, Gebäude 69, 22761 Hamburg, Germany — [3]Niels Bohr International Academy, Niels Bohr Institute, Blegdamsvej 17, 2100 Copenhagen, Denmark

We study few-boson tunneling in a one-dimensional double well with a spatially modulated interaction. The dynamics changes from Rabi oscillations in the non-interacting case to a highly suppressed tunneling for intermediate coupling strengths followed by a revival near the fermionization limit. The dynamics is explained on the basis of the few-body spectrum and stationary eigenstates. For higher number of particles, $N \geq 3$ it is shown that the inhomogeneity of interaction can be tuned to generate tunneling resonances. Finally a tilted double-well and its interplay with the interaction asymmetry is discussed.

A 9.3 We 11:00 F 303

Superconducting Atom Chips — Tobias Mueller[1,2], Rachele Fermani[1,2], Bo Zhang[1], Kin Sung Chan[1], Michael J. Lim[1,3], and •Rainer Dumke[1] — [1]School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore — [2]Centre for Quantum Technologies, National University of Singapor, Singapore — [3]Rowan University, New Jersey, USA

We store and control ultra-cold atoms in a new type of trap using magnetic fields of vortices in a high temperature superconducting microstructure. This is the first time ultra-cold atoms have been trapped in the field of magnetic flux quanta. We generate the attractive trapping potential for the atoms by combining the magnetic field of a superconductor in the remanent state with external homogeneous magnetic fields. We show the control of crucial atom trap characteristics such as an efficient intrinsic loading mechanism, spatial positioning of the trapped atoms and the vortex density in the superconductor. The measured trap characteristics are in good agreement with our numerical simulations.

A 9.4 We 11:15 F 303

Rotating three-dimensional solitons in Bose Einstein condensates with attractive nonlocal interaction — Fabian Maucher[1], Stefan Skupin[1,2], and •Wieslaw Krolikowski[3] — [1]Max Planck Institute for the Physics of Complex Systems — [2]Friedrich-Schiller-University, Institute of Condensed Matter Theory and Solid State Optics, 07743 Jena, Germany — [3]Laser Physics Centre, Research School of Physics and Engineering, Australian National University, Canberra, ACT 0200, Australia

We study the dynamics of rotating high order solitons (azimuthons) in Bose Einstein condensates with attractive nonlinear, nonlocal and isotropic interaction. In particular, we consider a “Gaussian” and a “1/r”-response, i.e., prototypes for short and long-range interaction. Azimuthons are a straightforward generalization of usual (nonrotating) solitons and feature an additional parameter, the angular frequency. The most simple three-dimensional azimuthons are tori with angular phase ramp and azimuthal amplitude modulations. Approximate variational methods allow a rather good approximation of the angular velocity of the azimuthons (compared to full 3d numerical simulation). It is possible to control this angular frequency by varying the repulsive contact interaction using Feshbach resonance techniques. The observed structures are very robust, even in cases where the initial conditions are rather far from the exact solutions. We conjecture that self-trapped azimuthons are generic for condensates with attractive nonlocal interaction.

A 9.5 We 11:30 F 303

Two-way conversations between cold atoms and semiconductors — •Thomas Judd[1,2], Robin Scott[2], German Sinuco[2], Tom Montgomery[2], Andrew Martin[3], Peter Krüger[2], and Mark Fromhold[2] — [1]University of Tübingen, Germany — [2]University of Nottingham, UK — [3]University of Melbourne, Australia

There has been significant work in the past few years on hybrid devices which combine cold atoms with solid state structures. The hope is to create devices which combine the key advantages of both systems - the purity of a quantum coherent atom cloud, and the versatility of microchips - to study fundamental physics and further quantum technologies. To date there has been much success in manipulating cold atoms with microchips and semiconductors to create a measurable signal in the atom cloud. However, it has not been possible to perform the reverse procedure of using cold atoms to create a measurable signal in a solid state device. If this two-way coupling can be achieved, a range of possibilities open up such as long-term quantum memory chips. Here we use simulations to show that Fresnel zone plates could assist these efforts by strongly and coherently focusing ultracold atoms onto a semiconductor chip with a two-dimensional electron gas (2DEG). The atoms are shown to deplete the 2DEG, thereby strongly increasing its resistivity to measurable levels. The technique provides a solution to the long standing problem of short-range atom focusing while at the same time opening the door to a new form of non-destructive lithography which can create electronic components on a 50nm scale.

A 9.6 We 11:45 F 303

An AC electric trap suitable for ground-state CO molecules — •Amudha Kumari Duraisamy, Adela Marian, Wieland Schöllkopf, and Gerard Meijer — Fritz-Haber-Institut, Faradayweg 4-6, Berlin, Germany

When trapping polarizable neutral particles using AC electric fields, the parameter which determines the strength of the interaction is α/m, where α is the (total) quadratic Stark coefficient and m is the mass of the particle. As this ratio is nearly identical for ^{87}Rb and ^{12}CO in their ground states, they would behave very similarly when confined in an AC electric trap. We have already demonstrated and studied trapping of ground-state Rb in a macroscopic AC electric trap with a depth of a few microkelvins [1, 2] . We now propose to use the Rb atoms as a case study for the behaviour of AC-trapped ground-state CO molecules.

To this end, we have implemented a new AC trap where all the dimensions were scaled down by a factor of two to increase the available trap depth. Stable electric trapping is observed in a wider range of switching frequencies around 300 Hz, in agreement with trajectory calculations. We have trapped about 1.3×10^5 atoms with densities of 8×10^9 cm^{-3} for an electric field of 60 kV/cm at the center of the trap.

Refrences
1. S. Schlunk et al., PRL **98**, 223002(2007),
2. S. Schlunk et al., PRA **77**, 043408(2008)

A 9.7 We 12:00 F 303

Gap and screening in Raman scattering of a Bose condensed gas — •Patrick Navez[1] and Kai Bongs[2] — [1]Universitaet Duisburg-Essen, Lotharstrasse 1, 47057 Duisburg, Germany — [2]University of Birmingham, Edgbaston, Birmingham, B15 2TT, England

We propose different spectroscopic methods to explore the nature of the thermal excitations of a trapped Bose condensed gas: 1) a four photon process to probe the uniform region in the trap center: 2) a stimulated Raman process in order to analyze the influence of a momentum transfer in the resulting scattered atom momentum distribution. We apply these methods to address specifically the energy spectrum and the scattering amplitude of these excitations in a transition between two hyperfine levels of the gas atoms. In particular, we exemplify the potential offered by these proposed techniques by contrasting the spectrum, expected from the non conserving Bogoliubov approximation valid for weak depletion, to the spectrum of the finite temperature extensions like the conserving generalized random phase approximation (GRPA). Both predict the existence of the Bogoliubov collective excitations but the GRPA approximation distinguishes them from the single atom excitations with a gapped and parabolic dispersion relation and accounts for the dynamical screening of any external perturbation applied to the gas. Two feasible experiments are discussed, one concerns the observation of the gap associated to this second branch of excitations and the other deals with this screening effect. Ref: P. Navez and K. Bongs, Eur. Phys. Lett. (in press).

A 9.8 We 12:15 F 303

Cold atoms near superconductors — •Helge Hattermann, Florian Jessen, Brian Kasch, Daniel Cano, Max Kahmann, Dieter Koelle, Reinhold Kleiner, and József Fortágh — Physikalisches Institut, Eberhard-Karls-Universität Tübingen, CQ Center for Collective Quantum Phenomena and their Applications, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

We report on the measurement of atomic spin coherence near the surface of a superconducting niobium wire. As compared to normal conducting metal surfaces, the atomic spin coherence is maintained for time periods beyond the Johnson noise limit. The result provides experimental evidence that magnetic near field noise is strongly suppressed close to the superconductor. For very small distances to the wire surface, the magnetic field exclusion due to the Meissner effect reduces the trap depth and leads to atom losses. Based on our results, we discuss possibilities to circumvent these detrimental losses and to coherently couple ultracold atoms to solid state devices, opening the way towards the construction of hybrid quantum systems.

A 10: Precision Spectroscopy of Atoms and Ions I

Time: Wednesday 10:30–12:30 Location: F 107

Invited Talk A 10.1 We 10:30 F 107

The promises and challenges of precision spectroscopy of cold molecules — •Steven Hoekstra — KVI, University of Groningen, The Netherlands

In recent years the activity in the field of 'cold molecules' has increased rapidly. Atomic physicists are eager to expand the experiments that have worked so well using cold atoms; chemists are dreaming of studying completely controlled reactions. Together researchers from a variety of backgrounds are developing the required theoretical and experimental tools. In this talk an overview of the promises and challenges of the research on cold molecules is given, with special attention for the possibilities to test fundamental interactions and symmetries using precision spectroscopy of cold molecules.

A 10.2 We 11:00 F 107

Nuclear isotope implications on atomic parity-violation experiments with He-like ions — •Fabrizio Ferro[1,2], Anton Artemyev[1,2], and Andrey Surzhykov[1,2] — [1]Physikalisches Institut, Universität Heidelberg — [2]GSI, Darmstadt

During the last two decades, atomic parity-violation (PV) studies with few-electron heavy ions have attracted much interest both in experiment and theory. For high-Z, helium-like ions, in particular, a number of experiments were proposed to measure the parity mixing between (almost degenerate) $2\,^3P_0$ and $2\,^1S_0$ states. For example, Schäfer and co-workers [1] have suggested to apply very intense laser beams (of order 10^{21} W/cm^2) in order to induce parity-violating 2E1 transition between these two levels. For the practical realization of such an experiment precise information is needed on the $2\,^3P_0$ - $2\,^1S_0$ energy splitting. In this contribution, we performed a systematic study of the energy spectrum of helium-like ions with nuclear charges in the ranges 54<Z<71 and 88<Z<92, i.e. in the regions where PV effects are expected to be most significant. To this purpose, we adopted a relativistic many-body perturbation theory to all orders and included quantum electrodynamics (QED) corrections. Special attention in our study is paid to the isotope shifts of 2 $^3P_0$ and 2 $^1S_0$ levels. Based on detailed calculations we show, for example, that by choosing appropriate isotopes one may tune the 2 $^3P_0$ - 2 $^1S_0$ splitting in the working range of very high intensity lasers (e.g. PHELIX at GSI).

[1] A. Schäfer et al., Phys. Rev. A 40 (1989) 7362

A 10.3 We 11:15 F 107

Rydbergserien in Lanthaniden und Aktiniden zur Bestimmung erster Ionisationspotentiale — •Tina Gottwald, Amin Hakimi, Christoph Mattolat, Sebastian Raeder und Klaus Wendt — Institut für Physik, Universität Mainz, 55128 Mainz

In ihrem äußerst komplexen Spektrum weisen alle Elemente der Gruppe der Lanthaniden und Aktiniden eine Vielzahl verschiedener Zustände in der Umgebung ihres ersten Ionisationspotentiales auf. Neben Rydberg- und autoionisierenden Rydbergzuständen existieren im gleichen Energiebereich zahlreiche Zustände, bei denen die Anregungsenergie auf mehrere Elektronen aufgeteilt ist. Die letzteren Zustände erschweren eine Identifikation kontinuierlicher Rydbergserien signifikant oder machen diese gar unmöglich.

Die Analyse von Rydbergkonvergenzen ist aktuell die genaueste Methode, das erste Ionisationspotential eines Elementes zu bestimmen. Diese fundamentale Größe ist aufgrund der Schwierigkeiten, Rydbergserien bei Lanthaniden und Aktiniden zu identifizieren, bei einigen dieser Elemente bisher nur mit unbefriedigender Genauigkeit bekannt. Experimentelle Studien zu Rydbergserien in Lanthaniden und Aktiniden wurden mit Hilfe mehrstufiger Laserresonanz-Ionisationsspektroskopie durchgeführt. Konzepte zur Trennung der Rydbergzustände von übrigen Zuständen werden vorgestellt und aktuelle Ergebnisse zu Ionisationspotentialen präsentiert.

A 10.4 We 11:30 F 107

Auf dem Weg zur Laserspektroskopie der Hyperfeinstruktur in Li-ähnlichem ^{209}Bi^{80+} — •Matthias Lochmann[1,2], D. Anielski[4], C. Brandau[2,5], D.A. Church[6], A.J. Dax[3], C. Geppert[1], V. Hannen[4], G. Huber[1], T. Kühl[2], C. Novotny[1], R. Sánchez[1,2], D.H. Schneider[7], V.M. Shabaev[8], T. Stöhlker[2,10], R.C. Thompson[9], A.V. Volotka[8,11], C. Weinheimer[4], D.F.A. Winters[2,10] und W. Nörtershäuser[1] — [1]Universität Mainz — [2]GSI, Darmstadt — [3]CERN, Genf — [4]Universität Münster — [5]TU München, Garching — [6]Texas A&M University, USA — [7]LBNL Berkeley — [8]St. Petersburg State University — [9]Imperial College, London — [10]Universität Heidelberg — [11]TU Dresden

Durch Messung der Hyperfeinstrukturaufspaltung (HFS) in H-ähnlichen schweren Ionen kann die Quantenelektrodynamik (QED) in extremen elektromagnetischen Feldern getestet werden. Bisher ist die räumliche Verteilung des kernmagnetischen Moments und dessen Einfluss auf die HFS (Bohr-Weisskopf-Effekt) mit zu großer Unsicherheit belastet, um QED-Effekte zu separieren. Ein Vergleich der HFS-Aufspaltung von H- und Li-ähnlichen Ionen kann dies jedoch ermöglichen [1]. ^{209}Bi ist für einen QED-Test gut geeignet, da sowohl die H- als auch die Li-ähnlichen Ionen HFS-Übergänge im Laserwellenlängenbereich haben. Mittels kollinearer Laserspektroskopie am Experimentierspeicherring ESR der GSI soll die HFS von Li-ähnlichem Bismut deutlich präziser als bisher vermessen werden.

[1] V. M. Shabaev *et al.*, PRL **86**, 3959 (2001)

A 10.5 We 11:45 F 107

Spectral properties of unnatural parity states of two-electron atoms — •Sebastian Schröter[1], Johannes Eiglsperger[1], Bernard Piraux[2], and Javier Madroñero[1] — [1]Technische Universität München — [2]Université catholique de Louvain

In recent years a lot of effort has been invested into the study of the spectral properties of helium states. Most of these studies are devoted to natural parity states (e.g, states that can be accessed through linearly polarized dipole transitions from the ground state). However, there are rather few investigations [1] on unnatural parity states which are in the focus of this contribution. The knowledge of accurate values of such energy levels is important not only in the context of atomic physics but also in various fields like astrophysics (e.g., for the understanding of lines observed in the solar corona) and plasma physics for diagnostics and understanding of high temperature processes. We present a detailed study of the spectral properties of such states in a planar model [2] and in a full three dimensional approach [3] for several angular momenta and for a rather wide energy range which includes bound states (below the second single ionization threshold (SIT)) and resonances up to the eighth SIT.

[1] J. K. Saha and T. K. Mukherjee, Phys. Rev. A **80**, 022513 (2009).
[2] J. Eiglsperger and J. Madroñero, Phys. Rev. A **80**, 022512 (2009).
[3] J. Eiglsperger, B. Piraux, and J. Madroñero, Phys. Rev. A **80**, 022511 (2009).

A 10.6 We 12:00 F 107

Entwurf einer zylindrischen Penningfalle zur Detektion des Spinzustandes eines einzelnen isoliert gespeicherten 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

Beim Experiment zur direkten, nicht-destruktiven Messung des g-Faktors eines einzelnen gespeicherten Protons wird eine Doppel-Penningfalle zylindrischer Geometrie eingesetzt. Eine Messgenauigkeit von 10^{-9} wird angestrebt. Das elektrostatische Potential der zylindrischen Geometrie weicht vom perfekten Quadrupolpotential ab, was durch Anbringung zusätzlicher Korrekturelektroden kompensiert werden muss. Durch geeignete Wahl der Elektrodengeometrie kann das Potential optimiert werden, so dass simultan eine geringe Energieabhängigkeit der Eigenfrequenzen und Unabhängigkeit der Teilchenfrequenz von der an den Korrekturelektroden angelegten Spannung gewährleistet wird. Beides begünstigt die Präzisionsmessung. Zur Bestimmung des g-Faktors muss die Larmorfrequenz des Protons in der Falle über eine Spinflipresonanz ermittelt werden. Die Detektion des Spinzustandes erfolgt in einer weiteren Penningfalle, in der eine magnetische Inhomogenität durch eine ferromagnetische Ringelektrode eingebracht wird. Das Design der Fallenelektroden basierend den Resultaten von Simulationsrechnungen wird präsentiert.

A 10.7 We 12:15 F 107

Bound electron g-Factor Measurement by Double-Resonance Spectroscopy on a Fine-Structure Transition — •David von Lindenfels[1,2], Nicolaas P. M. Brantjes[1,2], Wolfgang Quint[1,2], and Manuel Vogel[1,3] — [1]GSI Darmstadt, Germany — [2]Universität Heidelberg, Germany — [3]Imperial College, London, UK

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. We designed a cryogenic trap assembly with a creation trap and a spectroscopy trap — a half-open compensated cylindrical Penning 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. Thus, the experiment allows to test QED predictions with high accuracy. 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 talk presents techniques and the current status of the experiment.

A 11: Interaction with VUV and X-Ray Light I

Time: Wednesday 10:30–12:30 Location: B 302

A 11.1 We 10:30 B 302

Two-Photon double ionization of He at FLASH — •Moritz Kurka[1], Artem Rudenko[2], Lutz Foucar[2], Kai-Uwe Kühnel[1], Yuhai Jiang[1], Oliver Herrwerth[3], Matthias Lezius[3], Matthias Kling[3], Jeroen van Tilborg[4], Ali Belkacem[4], Michael Schulz[5], Stefan Düsterer[6], Rolf Treusch[6], Claus Dieter Schröter[1], Robert Moshammer[1], and Joachim Ullrich[1,2] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Max-Planck Advanced Study Group at CFEL, 22607 Hamburg, Germany — [3]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany — [4]Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA — [5]Physics Department and LAMOR, University of Missouri-Rolla, Rolla, MO 65409, USA — [6]DESY, 22607 Hamburg, Germany

Free electron lasers such as the FLASH which started operation in 2005 deliver light at unprecedented intensities in the VUV region. Hence they enable for the first time to probe fundamental non-linear few-photon processes in this spectral region. One prominent example is the so called direct channel in two-photon double ionization of Helium, where the absorption of two photons leads to a direct transition from the ground state of the neutral atom to the doubly ionized continuum. This channel serves as an ideal testing ground for effects due to electron-electron correlation in non-linear ionization reactions and therefore sparked substantial theoretical interest in the last few years [1]. Here we report on the first differential measurements on this reaction at two different photon energies.

[1] J. Feist et al., PRA 77, 043420 (2008).

A 11.2 We 10:45 B 302

Two-Photon Inner Shell Ionization in the Extreme-Ultraviolet — •Vincent Richardson[1], John T. Costello[1], Denis Cubaynes[2], Stefan Düsterer[3], Josef Feldhaus[3], Hugo van der Hart[4], Pavle Juranic[3], Wenbin Li[3], Michael Meyer[2], Mathias Richter[5], Andrey A. Sorokin[3,5,6], and Kai Tiedtke[3] — [1]National Centre for Plasma Science and Technology, Dublin City University, Dublin 9, Ireland — [2]LIXAM/CNRS, Centre Universitaire Paris-Sud, Bâtiment 350, 91405 Orsay Cedex, France — [3]Deutsches Elektronen-Synchrotron, DESY, Notkestrasse 85, 22603 Hamburg, Germany — [4]Dept. of Appl. Mathematics and Theoretical Physics, David Bates Bldg., Queen's University Belfast — [5]Physikalisch-Technische Bundesanstalt, PTB, Abbestraße 2-12, 10587 Berlin, Germany — [6]Ioffe Physico-Technical Institute, Polytekhnicheskaya 26, 194021 St. Petersburg, Russia

We have observed the simultaneous inner-shell absorption of two extreme-ultraviolet (EUV) photons by a Xe atom in an experiment performed at the short-wavelength free-electron laser (FEL) facility FLASH in Hamburg. Photoelectron measurements permitted us to unambiguously identify a feature resulting from the single ionization of the 4d sub-shell of Xe by two photons each of energy 93 eV. In addition, we were able to track its intensity dependence which varies quadratically with the pulse energy. The results are discussed and interpreted within the framework of recent results of ion spectroscopy on Xe obtained at ultra-high EUV irradiance (PRL 99 (2007) 213002; PRL 102 (2009) 163002).

A 11.3 We 11:00 B 302

Measurement of the angular correlation function of photoelectrons and dispersed fluorescence photons on rare gas atoms after excitation with synchrotron radiation — •Andre Knie[1], Rainer Hentges[1], Markus Braune[2], Markus Ilchen[3], Ingo Holtkoetter[4], Sascha Deinert[3], Andre Meissner[2], Sanja Korica[2], Uwe Becker[2], and Arno Ehresmann[1] — [1]Institute of Physics and CINSaT, University of Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany — [2]Fritz-Haber-Institut der MPG, 14195 Berlin — [3]DESY, 22607 Hamburg — [4]WWU Muenster, 48149 Muenster

For the first time an angle-resolving photoelectron spectrometer was used in coincidence with an angle-resolving dispersed fluorescence spectrometer. The experiment is equipped with five electron TOFs and - via a parabolic mirror - with a 0.5 m Wadsworth mount-like monochromator and was performed with synchrotron radiation from the UE 56/2 PGM1 beamline at BESSY II.

While the angle information of the electrons is collected traditionally, the fluorescence photons are reflected by a parabolic mirror. This mirror translates the angular information into position information within a parallel fluorescence light beam. After being dispersed it is possible to record wavelength selectively and angle resolved fluorescence in coincidence with angle resolved photoelectrons.

A 11.4 We 11:15 B 302

Study of multiple ionization of Ne, Ar and Xe induced by intense XUV femtosecond laser pulse — •Roland Guichard, Myroslav Zapukhlyak, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden, Germany

Recently, an experiment performed at FLASH in Hamburg showed that xenon atoms irradiated with intense XUV femtosecond laser pulses can be ionized up to Xe+21 [1]. In order to shed more light onto these processes, we have performed ab-inito calculations based on time-dependent density functional theory. Additionally, we present results on two less involved cases, namely Ne and Ar for which experimental data have also been recorded [2,3]. Taking into account the spatio-temporal pulse dependence is required for a reliable comparison of the experimental data with the theory.

[1] A. Sorokin et al., Phys. Rev. Lett. 99, 213002 (2007)
[2] M. Richter et al., Phys. Rev. Lett. 102, 163002 (2009)
[3] K. Motomura et al., J. Phys. B 42, 221003 (2009)

A 11.5 We 11:30 B 302

First results of the CAMP Instrument Commissioning at LCLS — •Benjamin Erk[1], Daniel Rolles[1], Artem Rudenko[1], Sascha W. Epp[1], Lutz Foucar[1], Benedikt Rudek[1], Robert Hartmann[2], Nils Kimmel[2], Christian Reich[2], Peter Holl[2], Lothar Strüder[1,2], Ilme Schlichting[1,3], and Joachim Ullrich[1,4] — [1]Max Planck Advanced Study Group at CFEL, Hamburg, Germany — [2]Max Planck Halbleiterlabor, München, Germany — [3]Max-Planck-Institut für medizinische Forschung, Heidelberg, Germany — [4]Max-Planck-Institut für Kernphysik, Heidelberg, Germany

The first x-ray Free-Electron Laser came online this fall at the SLAC National Accelerator Laboratory. The AMO beamline of the Linac Coherent Light Source (LCLS) delivers ultra-intense extremely short x-ray pulses down to a few femtoseconds pulse duration at photon energies of 0.8 to 2 keV. The Max Planck Advanced Study Group (ASG) at the Center for Free Electron Laser Science (CFEL) has designed a multi-purpose experimental end station (CFEL-ASG Multi-Purpose chamber - CAMP) especially adapted for the use of unique large-area, single-photon counting pnCCD detectors, developed by the Max Planck Institute semiconductor laboratory, together with advanced many-particle ion and electron imaging spectrometers (reaction microscope; velocity map imaging). The general layout and capabilities of the CAMP instrument will be reviewed and results of the successful instrument commissioning that took place during early LCLS user runs in fall 2009 will be reported. In addition, a brief overview of the first LCLS experiments conducted in CAMP will be given.

A 11.6 We 11:45 B 302

Correlated measurements of fluorescence and ion spectra after X-FEL Ionization of Atoms and Molecules — •Benedikt Rudek[1], Daniel Rolles[1], Artem Rudenko[1], Sascha W. Epp[1], Lutz Foucar[1], Benjamin Erk[1], Robert Hartmann[2], Nils Kimmel[2], Christian Reich[2], Peter Holl[2], Lothar Strüder[1,2], Ilme Schlichting[1,3], and Joachim Ullrich[1,4] — [1]Max Planck Advanced Study Group at CFEL, Hamburg — [2]Max-Planck Halbleiterlabor, München — [3]Max-Planck-Institut für medizinische Forschung, Heidelberg — [4]Max-Planck-Institut für Kernphysik, Heidelberg

With its combination of unique large-solid-angle photon and state of the art charged particle detection devices the CFEL-ASG Multi-Purpose (CAMP) instrument is designed to house a broad variety of experiments at x-ray free electron lasers.

The CAMP chamber was recently commissioned at the first X-ray FEL, the LCLS at SLAC. Its capability for correlated measurements of fluorescence, photo diffraction, ion time of flight and ion momentum distribution was examined by the Max Planck Advanced Study Group and then employed during the first two very successful runs using a variety of different targets and detector combinations.

In the particular setup discussed in this talk pnCCDs and time and space resolving spectrometers were grouped around the intersection of the X-FEL beam and a supersonic gas jet to simultaneously collect data on fluorescent photons and recoil ions respectively. Preliminary results for X-ray ionization of rare gases and molecules will be reported.

A 11.7 We 12:00 B 302

Nonperturbative multiphoton electron-positron pair creation in strong laser fields — •Matthias Ruf, Guido R. Mocken, Carsten Müller, Antonino Di Piazza, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Heidelberg

The generation of electron-positron pairs from vacuum in counterpropagating laser beams is investigated [1]. Our particular interest lies in the nonperturbative multiphoton regime and the resonance structure of the process. By combining analytical and numerical methods we obtain rich information on momentum spectra, resonance widths, and the time dependence of the creation probability, both on and off the resonance. The impact of the laser magnetic field is also addressed [2].

Moreover, we discuss tunneling pair production in a sub-critical laser field and a nuclear field, and demonstrate the possibility of controlling the tunneling barrier by the assistance of a high-energy photon [3].

[1] G. R. Mocken *et al.*, Phys. Rev. A, in print
[2] M. Ruf *et al.*, Phys. Rev. Lett. 102, 080402 (2009)
[3] A. Di Piazza *et al.*, Phys. Rev. Lett. 103, 170403 (2009)

A 11.8 We 12:15 B 302

From wave packet dynamics in MgH ions to X-ray structural analysis — •Steffen Kahra[1], Günther Leschhorn[1], Tobias Schaetz[1], Agustin Schiffrin[2], Ralph Ernstorfer[2], Reinhard Kienberger[2], Markus Kowalewski[3], and Regina de Vivie-Riedle[3] — [1]MPQ, Garching, TIaMo — [2]MPQ, Garching, AS beam lines — [3]Chemie und Biochemie, LMU München

We report measurements that demonstrate the combination of precise spatial control and initialization of single molecular ions in a Paul trap with temporal resolution provided by <5 fs UV laser pulses. In this proof of method experiment we show how the temporal evolution of a vibrational wave packet in a few distinguishable isolated molecules can be followed by a dissociative pump probe scheme. This experiment can be seen as a first step on the way towards time resolved diffraction experimentes on single particles since it contains important functional components of the envisioned machine already. It is our aim to load, trap, cool and initialize molecular ions at a well defined (<1 micrometer) and known position in space in a repeatable manner in order to prepare the most suitable target for, e.g. structural analysis of molecular ions by diffraction of short and intense X-ray pulses. We describe the way to load and identify individual molecular ions in our trap and especially concentrate on how to count them reliably before and after the pump probe delay dependent dissociation. But other building blocks needed to realize the ideal target for diffraction experiments will be highlighted as well. Some of them are already proven to work in our apparatus others are prepared but still need to be connected.

A 12: Atomic Clusters I

Time: Wednesday 14:00–16:00 Location: F 303

Invited Talk A 12.1 We 14:00 F 303

Sequential two-photon double ionization of atoms in intense FEL radiation — •Stephan Fritzsche[1,2], Alexei N. Grum-Grzhimailo[3], Elena V. Gryzlova[3], and Nikolay M. Kabachnik[3] — [1]Department of Physics, University of Oulu, Finland — [2]GSI Helmholtzzentrum für Schwerionenforschung, Germany — [3]Institute of Nuclear Physics, Moscow State University, Russia

Recent progress in the generation of intense FEL radiation has opened a new avenue for studying non-linear processes of atoms and molecules in the XUV and x-ray regime. Among these processes, the two-photon double ionization (TPDI) has received much interest since it enables one to explore in detail the transition from a 'sequential' towards the 'simultaneous' emission of two or more electrons. In this talk, I shall discuss this process for different noble gases and for its parametrization in terms of the alignment and dynamical behaviour of the photoions in their intermediate and final states. Results from different computational models [1] are presented and compared with recent experiments [2,3]. Apart from modifications on the (individually) observed photo-electron distributions due to multi-photon absorption, emphasis is placed also on the electron-electron correlation (function) if the two photo-electrons are detected in coincidence.

[1] S. Fritzsche *et al.*, J. Phys. B **41** (2008) 165601; B **42** (2009) 145602.
[2] M. Braune *et al.*, *Intern. Conf. on Photonic, Electronic and Atomic Collisions (ICPEAC 2007)*, Freiburg, Germany, Abstract Fr034.
[3] M. Kurka *et al.*, J. Phys. B **42** (2009) 141002(FT).

Invited Talk A 12.2 We 14:30 F 303

Few-body physics with ultracold atoms — •Selim Jochim[1,2], Thomas Lompe[1,2], Martin Ries[1,2], Friedhelm Serwane[1,2], Philipp Simon[1,2], Andre Wenz[1,2], and Gerhard Zürn[1,2] — [1]Physikalisches Institut, Universität Heidelberg — [2]Max-Planck-Institut für Kernphysik, Heidelberg

During the past years, ultracold atoms have been a fantastic playground to study few-body physics in the universal regime, in which the properties of bound states do not depend on particular details of the interatomic potential, but only on a few numbers, such as the scattering length. The major ingredient in current experiments is the tunabilty of the scattering length using an externally applied magnetic field using Feshbach resonances. In 2003, this allowed the creation of diatomic Feshbach-molecules, which have been an important starting point for many important milestones, such as the realization of the BEC-BCS crossover, or the controlled preparation of ultracold ground state molecules. Associated with every universal two-body bound state is an infinite series of three-body bound states, as was predicted in 1970 by Vitaly Efimov. Such Efimov states have first been observed in 2006 with ultracold bosonic Cs atoms in the form of three-body scattering resonances. More recently, our group has found evidence for universal three body bound states between three distinguishable fermionic ^{6}Li atoms. Such a three-component system offers the possibility to study many body physics which because of its SU(3)-symmetry could resemble the simplest models of QCD.

A 12.3 We 15:00 F 303

Clusters in XUV laser pulses: Electron emission and nanoplasma dynamics — •Mathias Arbeiter und Thomas Fennel — Institute of Physics, University of Rostock

The excitation mechanisms of clusters exposed to intense laser fields in the VUV and XUV domain strongly differ from the response behavior in the near-infrared wavelength range. Whereas the heating of delocalized electrons in the nanoplasma is the dominant energy capture mechanism in optical fields, energy absorption due to the excitation of localized electrons, i.e. by the inner ionization processes itself, becomes increasingly important at high photon energy. Further, the formation of a nanoplasma is substantially delayed because of direct electron excitation into the continuum. The resulting signatures in electron energy spectra[1] can be described by a multi-step ionization scheme[2].

In addition, future prospects will be addressed for XUV pump-and-probe experiments, e.g. for monitoring nanoplasma built-up, cluster expansion and dark plasmon modes.

[1] C. Bostedt et al., Phys. Rev. Lett. 100, 133401 (2008)
[2] M. Arbeiter, Th. Fennel, in preparation

A 12.4 We 15:15 F 303

Dichte Xenon- und Silbernanoplasmen in starken Laserfeldern — •Paul Hilse[1], Thomas Bornath[2], Max Moll[1] und Manfred Schlanges[1] — [1]Ernst-Moritz-Arndt-Universität Greifswald — [2]Universität Rostock

Die Wechselwirkung intensiver Laserstrahlung mit Xenon- und Silberclustern mit Größen im nm-Bereich wird im Rahmen eines modifizierten Nanoplasma-Modells [1] untersucht. Von besonderem Interesse ist die Ionisationsdynamik im lasererzeugten dichten Plasma. Es zeigt sich, dass sich die Dynamik, d.h. die zeitliche Entwicklung von Dichte und Temperatur - und damit verbunden - die Plasmazusammensetzung, der untersuchten Elemente bei gleichen Laserparametern stark voneinander unterscheidet [2].

Eine Methode, die Dynamik des Plasmas gezielt auf der Skala von

Femtosekunden zu steuern, ist das sogenannte Pulse-Shaping. In unserem theoretischen Zugang benutzen wir einen genetischen Algorithmus zur Optimierung der Pulsform des Lasers, um die maximale Ausbeute einer bestimmten Ionenspezies zu erzielen [3]. Auch hier zeigt sich ein stark unterschiedliches Verhalten der betrachteten Elemente Xenon und Silber. Es werden Resultate mit optimierten Pulsformen gezeigt und mit Einzel- und Doppelpulsanregungen verglichen.

[1] P. Hilse, M. Moll, M. Schlanges, and Th. Bornath, Laser Physics, **19** 428 (2009) [2] P. Hilse, Th. Bornath, M. Moll, and M. Schlanges, Contrib. Plasma Phys. **49**, 692 (2009) [3] Truong et al., Optimal control of the strong field ionization of silver clusters in helium droplets, Phys. Rev. A (accepted Dec. 9, 2009)

A 12.5 We 15:30 F 303

Electronic Structure of Transition Metal Doped Gold Clusters — •Konstantin Hirsch[1], Jochen Rittmann[2], Vicente Zamudio-Bayer[1], Marlene Vogel[1], Jörg Wittich[1], Silvia Forin[1], Christian Kasigkeit[1], Felix Ameseder[1], Jürgen Probst[1], 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. A clear transition from planar to three dimensional geometric structures can be observed, since distinct atomic like features in the spectra vanish if the cluster undergoes the geometric transition. The spectra change dramatically upon successive addition of gold atoms to the cluster. Even electron localization in chromium doped gold clusters can be observed.

A 12.6 We 15:45 F 303

Electronic Properties of Transition Metal Doped Silicon Clusters — •Jochen Rittmann[1], Konstantin Hirsch[2], Christian Kasigkeit[2], Philipp Klar[2], Andreas Langenberg[1], Fabian Lofink[2], Jürgen Probst[2], Marlene Vogel[2], Jörg Wittich[2], Vicente Zamudio-Bayer[2], Thomas Möller[2], Bernd von Issendorff[3], and Tobias Lau[1] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie, Institut für Methoden und Instrumentierung der Synchrotronstrahlung, Albert-Einstein-Str. 15, 12489 Berlin — [2]Technische Universität Berlin, Institut für Optik und Atomare Physik, Hardenbergstr. 36, 10623 Berlin — [3]Universität Freiburg, Fakultät für Physik, Stefan-Meier-Str. 21, 79104 Freiburg

Size selected transition metal doped silicon clusters have been studied with resonant 2p x-ray absorption spectroscopy. Despite the different number of valence electrons, nearly identical local electronic structures are found at the dopant atoms in $TiSi_{16}^+$, VSi_{16}^+, and $CrSi_{16}^+$. Additional measurements of the direct 2p photoionization as well as spectroscopy on the valence electrons of MSi_n^+ clusters, (M=V, Ti, Cr; n=15-17) allow us to determine the band gab, which is predicted to be exceptional high for the very symmetric MSi_{16}^+ clusters (M=V, Ti, Cr). The experimental data can be understood in the spherical potential model. The data indicate strongly interlinked electronic and geometric properties: While the transition metal atoms impose a geometric rearrangement on the silicon cluster, the interaction with the highly symmetric silicon cage determines the electronic structure of the transition metal dopants.

A 13: Interaction with Strong or Short Laser Pulses I

Time: Wednesday 14:00–16:00 Location: F 107

Invited Talk A 13.1 We 14:00 F 107

Testing strong-field CED and QED with intense laser fields — •Antonino Di Piazza, Karen Z. Hatsagortsyan, Ben King, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Strong laser fields can be employed to test classical and quantum electrodynamics (CED and QED, respectively) under extreme conditions. A fundamental problem in electrodynamics is the “radiation reaction” problem: classically, an accelerated electron emits radiation and this emission alters the motion of the electron itself. The Landau-Lifshitz equation consistently describes the electron’s motion in an external field by including radiation reaction. We explore a new scenario in which this equation can be in principle tested experimentally for the first time and with presently available laser technology [1]. We will also briefly address quantum vacuum polarization effects. We demonstrate the possibility of observing electron-positron pair production in laser and nuclear fields, by controlling the tunneling barrier through the assistance of an additional high-energy photon [2]. Finally, by exploiting the quantum interaction among real photon in vacuum, we propose a double-slit-like experiment devoid of any material parts [3].

[1] A. Di Piazza, K. Z. Hatsagortsyan, and C. H. Keitel, Phys. Rev. Lett. **102**, 254802 (2009).
[2] A. Di Piazza *et al.*, Phys. Rev. Lett. **103**, 170403 (2009).
[3] B. King, A. Di Piazza, and C. H. Keitel, Nature Photonics (in press).

A 13.2 We 14:30 F 107

Study of electron-nuclear correlation using the multi-configuration time-dependent Hartree approach — •Chirag Jhala and Manfred Lein — Centre for Quantum Engineering and Space-Time Research (QUEST) and Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany.

The multi-configuration time-dependent Hartree (MCTDH) approach [1] is a well known tool to study the nuclear dynamics in multi-dimensional systems. The extension of the MCTDH approach to study multi-electron dynamics is known as the multi-configuration time-dependent Hartree Fock (MCTDHF) approach. We propose to use the MCTDH approach to study the correlated electron-nuclear dynamics in H_2^+ and H_2 model systems driven by strong laser pulses. We evaluate various observables, e.g. high-harmonic generation (HHG) spectra, frequency-time analysis, fragmentation and survival probabilities and time-dependent densities, to compare the performance of MCTDH approach with the exact calculation. We demonstrate that the performance of MCTDH approach converges towards the exact results with increasing number of configurations and that a moderate number of configurations is sufficient to yield reliable results.

[1] M. H. Beck, A. Jäckle, G. A. Worth and H.-D. Meyer, Physics Reports **324**, 1 (2000).

A 13.3 We 14:45 F 107

Complete QED theory for trident pair production in strong laser fields — •Huayu Hu, Carsten Müller, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Heidelberg

The creation of electron-positron pairs in strong laser fields is encountering a growing interest in recent years. It has been stimulated by a pioneering experiment at SLAC [1] which realized multiphoton pair production in relativistic electron-laser collisions for the first time. Here, we develop a complete laser-dressed QED description of this process, which treats the competing reaction channels involved in a unified way. We calculate the dependence of the production rate on the laser parameters as well as the angular and momentum distributions of the three final-state particles. An overall good agreement with the measurements is obtained. We also study the process in a manifestly nonperturbative domain.

[1] D. Burke et al., Phys. Rev. Lett. 79, 1626 (1997)

A 13.4 We 15:00 F 107

Relativistic high-order harmonic generation: Drift compensation and phase coherence — •Markus C. Kohler, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Heidelberg, Deutschland

The progress in the high-order harmonic generation (HHG) with atomic targets above photon energies of 10 keV is hindered by relativistic effects. We put forward strategies to counteract the relativistic drift [1,2] and to achieve phase-matching at a high free-electron background for HHG in the relativistic regime. A complete, quantitative analysis of the macroscopic HHG yield from a gas jet for relativistic laser intensities is presented. Crucial issues influencing the efficiency are discussed. Two setups are considered: The driving field for HHG is either the field of counterpropagating strong attosecond pulses or that of an infrared laser field assisted by ultraviolet photons. The phase matching is achieved by either employing the additional HHG phase depending on the time delay between the driving pulses or quasi-phase matching schemes. In the optimized conditions, HHG with photon energies of several tenths of keV is feasible.

[1] K. Z. Hatsagortsyan, M. Klaiber, C. Müller, M. C. Kohler, and C. H. Keitel, J. Opt. Soc. Am. B **25**, 93 (2008).
[2] M. Klaiber, K. Z. Hatsagortsyan, C. Müller, and C. H. Keitel, Opt. Lett. **33**, 411 (2008).

A 13.5 We 15:15 F 107

Magnetic Deflection TOF Imaging von Ionen aus Silbercluster in starken Laserfeldern — •Christian Schaal, Robert Irsig, Josef Tiggesbäumker und Karl-Heinz Meiwes-Broer — Inst. f. Physik, Universität Rostock

Bei der Analyse der Ionen aus der Coulombexplosion von Clustern beobachtet man extrem hohe Ladungszustände als auch enorme Rückstoßenergien (KE). Der Zusammenhang zwischen q und KE ist bislang erst wenig untersucht worden. Eine Möglichkeit bietet hier die Technik des Magnetic Deflection Time-of-Flight Imaging (MD-TOF). Sie wurde schon früher von Lezius et al. [1] zur Analyse hoch energetischer, vielfach geladener Ionen aus Coulombexplosion von Clustern vorgestellt. Die Ionen werden in einem Wiley-McLaren TOF-MS beschleunigt und entsprechend ihrer kinetischen Energie und q/m-Verhältnis durch ein homogenes Magnetfeld, rechtwinklig zur Ausbreitungsrichtung der Ionen, abgelenkt. Diese Technik haben wir nun durch die Verwendung eines zeit- und ortsempfindlichen Delay-Line-Detektors erweitert, und untersuchen die Ionisationsdynamiken von Metallclustern in intensiven Laserfeldern. Erste Ergebnisse von Energie- und Impulsverteilung von Silberionen aus Clustern ($N \sim 1200$) werden diskutiert.

[1] M. Lezius, S. Dobosz, D. Normand and M. Schmidt, Phys. Rev. Lett. **80, 2**, 261 (1998)

A 13.6 We 15:30 F 107

Coulomb Explosion of Clusters Irradiated with Intense Femtosecond X-Ray Pulses — •Sebastian Schorb[1], D. Rupp[1], M. Adolph[1], T. Gorkhover[1], T. Möller[1], N. Timneanu[2], J. Andreasson[2], B. Iwan[2], M. Seiwert[2], J. Haidu[2], K. Hoffmann[3], N. Kandadai[3], A. Helal[3], H. Thomas[3], J. Keto[3], T. Ditmire[3], G. Doumy[4], L. DiMauro[4], M. Hoener[5], B. Murphy[5], N. Berrah[5], J. Bozek[6], M. Messerschmidt[6], and C. Bostedt[6] — [1]Institut für Optik und Atomare Physik, Technische Universität Berlin — [2]Uppsala University — [3]Fusion Research Center, University of Texas — [4]Department of Physics, The Ohio State University — [5]Department of Physics, Western Michigan University — [6]LCLS, SLAC National Laboratory

Free Electron Lasers open the door for novel experiments such as single shot imaging of molecules. For the success of the imaging experiments a detailed understanding of the ligth – matter interaction in the x-ray regime is pivotal. We have performed first investigations about intense x-ray – cluster interaction with femtosecond pulses from the Linac Coherent Light Source (LCLS) free electron laser in Stanford. We have studied the Coulomb explosion of argon clusters as a function of intensity and pulse length. The ionization dynamics in the keV photon energy regime will be compared to previous experiments in the soft x-ray regime at FLASH.

A 13.7 We 15:45 F 107

Abhängigkeit der Populationswahrscheinlichkeit eines atomaren Zwei-Niveau-Systems von der Träger-Einhüllenden-Phase eines fs-Laserpulses — •Anne Harth[1,2], Daniel S. Steingrube[1,2], Thomas Binhammer[1,2], Fabian Elster[1,2], Luis Santos[2,3] und Uwe Morgner[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Hannover, Germany — [2]Quest: Center for Quantum Engineering and Space-Time Research, Hannover, Germany — [3]Institut für Theoretische Physik, Leibniz Universität Hannover, Hannover, Germany

Die Untersuchung von Effekten der Träger-Einhüllenden-Phase (CEP) von sub-10-fs-Laserpulsen in Wechselwirkung mit Atomen war bisher auf Ionisationsprozesse beschränkt und damit auch auf Laser-Verstärker-Systeme. Theoretische Arbeiten haben jedoch bestätigt, dass auch die Populationswahrscheinlichkeit gebundener atomarer Energie-Niveaus eine CEP- Abhängigkeit aufweist. Dieses eröffnet nun die grundsätzliche Möglichkeit, die CEP-Abhängigkeit direkt mit einem Laser-Oszillator mit Pulsenergien im nJ-Bereich untersuchen zu können.

Wir präsentieren ein theoretisches Modell, um den CEP-Effekt für unseren oktavbreiten CEP-stabilisierten Ti:Saphir-Laseroszillator in unterschiedlichen atomaren Systemen abzuschätzen. Auf dieser Basis werden die experimentellen Möglichkeiten und Grenzen diskutiert.

A 14: Atomic Clusters II

Time: Wednesday 16:30–18:15 Location: F 303

Invited Talk A 14.1 We 16:30 F 303

Stochastic Resonance Effects in open Bose-Einstein condensates — •Dirk Witthaut[1], Friederike Trimborn[2], and Sandro Wimberger[3] — [1]Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen, Germany — [2]Institut für theoretische Physik, Universität Hannover, Germany — [3]Institut für theoretische Physik, Universität Heidelberg, Germany

In our naive understanding noise and dissipation are distracting, hindering measurements and degrading coherences in quantum mechanics. A paradigmatic counterexample to this assertion is the effect of stochastic resonance in nonlinear dynamics, where the response of a system to an external driving assumes its maximum in the presence of an appropriate amount of thermal noise.

In this talk I will discuss stochastic resonance effects for an interacting Bose-Einstein condensate subject to dissipation. For instance, particle loss can restore the phase coherence of a two-mode BEC and repurify a strongly interacting condensate almost completely. Moreover, even the decay induced by a localized perturbation in an optical lattice shows a stochastic resonance effect: If the loss rate becomes too large, dark solitons form which effectively suppress decay.

Invited Talk A 14.2 We 17:00 F 303

CRASY: Correlated Rotational Alignment Spectroscopy — •Thomas Schultz — Max Born Institut Berlin, Max Born Str. 2A, 12489 Berlin

The field of multidimensional nuclear magnetic resonance spectroscopy can teach us how to correlate the information of multiple measurements, thereby multipliying the information content of specific measurements. In optical spectroscopy, such experiments are rare. Here we demonstrate such an experiment with the correlation of rotational and electronic structure through the combination of nonadiabatic alignment techniques and femtosecond pump-probe ionization spectroscopy. The resulting mass resolved rotational spectra (mass-CRASY) allows the assignment of rotational spectra for rare natural isotopes and the state-selective investigation of fragmentation channels. The correlation of photoelectron spectroscopy with rotational structure (electron CRASY) can resolve electronic structure in an isomer selective fashion. We present first data and discuss how the combination of CRASY with (almost) all types of optical spectroscopy will transform the field of gas phase spectroscopy.

A 14.3 We 17:30 F 303

Collective Modes of Laser Excited Electrons in Clusters — •Thomas Raitza[1], Igor Morozov[2], Heidi Reinholz[3,1], and Gerd Röpke[1] — [1]Institut für Physik, Universität Rostock; Universitätsplatz 3, 18055 Rostock, Germany — [2]Joint Institute for High Temperature of RAS; Izhorskaya, 13, build. 2, Moscow 125412, Russia — [3]Institut für Theoretische Physik, Johannes-Kepler-Universität Linz; 4040 Linz, Austria

Clusters of solid state densities can form nano plasmas after laser irradiation with intensities of $10^{13} - 10^{16}$ Wcm^{-2}. Optical properties of plasmas are related to correlation functions, see [1]. A *restricted MD simulations* scheme for finite systems is introduced in [2], answering the question of local thermal equilibrium of electrons inside a cluster after laser irradiation. Plasma properties like temperature and density are discussed, see [3]. Investigations of dynamical correlations for finite systems via *restricted MD simulations* are presented. Collective electron excitation modes are analysed using spherical harmonics. The spatially resolved momentum auto-correlation spectrum is interpreted in terms of collective electron excitation modes. Resonance frequencies are calculated and damping rates are discussed. Size effects of dynamical properties are investigated.

[1] H. Reinholz; *Ann. Phys. Fr.* **30**, N° 4 - 5 (2006).

[2] T. Raitza, H. Reinholz, G. Röpke, and I. Morozov; *J. Phys. A* **42**, 214048 (2009).

[3] T. Raitza, H. Reinholz, G. Röpke, I. Morozov, and E. Suraud; *Contrib. Plasma Phys.* **49**, 498 (2009).

A 14.4 We 17:45 F 303

Elektron-Ion-Stoßfrequenz in Edelgas-Clustern — •Max Moll[1], Paul Hilse[1], Manfred Schlanges[1], Thomas Bornath[2] und Vladimir P. Krainov[3] — [1]Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald, 17487 Greifswald — [2]Institut für Physik, Universität Rostock, 18051 Rostock — [3]Moscow Institute for Physics and Technology, 141700 Dolgoprudny, Moscow Region, Russia

Bei der Wechselwirkung von Edelgas-Clustern mit Femtosekunden-Laserpulsen werden Plasmen mit hoher Dichte und hoher Temperatur erzeugt. Die Aufheizung der Cluster wird maßgeblich durch inverse Bremsstrahlung der Elektronen, d.h. durch Elektron-Ion-Stöße bestimmt. Eine wesentliche Größe in diesem Zusammenhang ist die Elektron-Ion-Stoßfrequenz. Im Beitrag wird gezeigt, dass es wichtig ist, die elektronische Struktur der Edelgas-Ionen zu berücksichtigen, was mit Modellpotentialen gelingt. Abschirmeffekte durch das umgebende Plasmamedium werden ebenfalls in die Beschreibung einbezogen.

In weiten Parameterbereichen entsprechender Experimente kann die oftmals benutzte Bornsche Näherung nicht verwendet werden. Zur Beschreibung der Elektron-Ion-Streuung untersuchen wir die Elektron-Ion-Stoßfrequenz auf der Basis klassischer Transportquerschnitte für die Streuung von Elektronen an Edelgas-Ionen verschiedener Ladungszustände. Neben Xenon-Plasmen werden auch die Edelgase Argon und Krypton untersucht. Die Abhängigkeit der Ergebnisse von der kinetischen Energie der Elektronen und vom Ladungszustand der Ionen wird diskutiert. Die Resultate für das Modellpotential werden mit Rechnungen für die Streuung an Coulomb-Teilchen verglichen.

A 14.5 We 18:00 F 303

Krypton clusters in the focus of the LCLS X-ray laser — •Marcus Adolph[1], Tais Gorkhover[1], Sebastian Schorb[1], Christoph Bostedt[2], Thomas Möller[1], and team CAMP[3] — [1]IOAP TU-Berlin, Hardenbergstrasse 36, 10623 Berlin — [2]LCLS, Stanford — [3]see ref [1]

With the development of short wavelength Free-Electron-Lasers (FEL) a new tool for the analysis of matter-light interaction is available. Very recently, at the SLAC National Accelerator Laboratory, the Linac Coherent Light-Source (LCLS) came into operation. LCLS produces 5 fs to 400 fs, super-intense X-Ray pulses in the regime from 800 eV up to 2 keV.

During our first experiments at LCLS we studied the interaction of LCLS pulses with rare gas clusters. With large pnCCD detectors [1] single shot scattering patterns of single clusters were recorded and combined with time of flight data of highly charged cluster fragments. This contribution will present first results for krypton clusters. The ionisation dynamics of krypton clusters irradiated above and below the L1 edge will be compared.

[1] L. Strüder *et al.* Nucl. Instr. Meth., accepted for publication

A 15: Attosecond Physics I

Time: Wednesday 16:30–18:30 Location: F 107

A 15.1 We 16:30 F 107

Phasenanpassung Hoher Harmonischer Strahlung in einer Semi-infiniten Gaszelle — •Tobias Vockerodt[1,2], Daniel S. Steingrube[1,2], Emilia Schulz[1,2], Uwe Morgner[1,2,3] und Milutin Kovacev[1,2] — [1]QUEST Centre for Quantum Engineering and Space-Time Research, Hannover — [2]Institut für Quantenoptik, Leibniz Universität Hannover — [3]Laser Zentrum Hannover

Die systematische experimentelle Untersuchung von Phasenanpassungsbedingungen in einer Semi-Infiniten Gaszelle (SIGC) wird vorgestellt. Mit Hilfe zweier Edelgase (Helium und Xenon) werden verschiedene Parameter variiert und für die Harmonischenerzeugung optimiert. Die SIGC bietet neben einfacher Handhabung eine hoher Konversionseffizienz durch eine lange Wechselwirkungszone und die Möglichkeit zur Attosekunden-Pulserzeugung. Der konstante Druck ermöglicht, im Gegensatz zu gepulsten Gasdüsen, den Einsatz bei kHz-Repetitionsraten. Ferner ist die Teilchendichte in dieser Geometrie exakt bekannt, so dass ein direkter Vergleich mit Simulationsergebnissen möglich ist. In den Experimenten wird spektrale Aufspaltung und Blauverschiebung der Harmonischen Ordnungen in Abhängigkeit der Parameter beobachtet.

A 15.2 We 16:45 F 107

Emission times in high-order harmonic generation — Ciprian Constantin Chirila[1], Ingo Dreissigacker[1], •Elmar Vincent van der Zwan[1,2], and Manfred Lein[1] — [1]Centre for Quantum Engineering and Space-Time Research (QUEST) and Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany — [2]Institut für Physik, Universität Kassel, Heinrich-Plett-Str. 40, 31432 Kassel, Germany

We calculate the emission times of the radiation in high-order harmonic generation using the Gabor transform of numerical data obtained from solving the time-dependent Schrödinger equation in one, two, and three dimensions. Both atomic and molecular systems, including nuclear motion, are investigated. Lewenstein model calculations are used to gauge the performance of the Gabor method. The resulting emission times are compared against the classical simple-man's model as well as against the more accurate quantum-orbit model based on complex trajectories. The influence of the range of the binding potential (long or short) on the level of agreement is assessed. Our analysis reveals that the short-trajectory harmonics are emitted slightly earlier than predicted by the quantum-orbit model. This explains partially recent experimental observations for atoms and molecules [1]. Furthermore, we observe a distinct signature of two-center interference in the emission times for H_2 and D_2. Model calculations show the effect of the laser-induced bound-state dynamics on this interference.

[1] S. Hässler *et al.*, J. Phys. B **42**, 134002 (2009)

A 15.3 We 17:00 F 107

High-Order Harmonic Generation at 100 kHz Repetition Rate for Time-Resolved Two-Photon Photoemission — •Christoph Heyl[1,2], Jens Güdde[1], Anne L'Hullier[2], and Ulrich Höfer[1] — [1]Fachbereich Physik und Zentrum für Materialwissenschaften, Philipps-Universität, Marburg, Germany — [2]Department of Physics, Lund University, Lund, Sweden

Two-photon photoemission (2PPE) has been successfully used to study the electron dynamics of surfaces and interfaces with femtosecond time resolution. With most of the current experimental setups the detectable energies and parallel momenta of electrons are limited by the availability of ultra-short pulsed UV laser systems. Recent progress in generating femtosecond and attosecond VUV pulses by means of high-order harmonic generation (HHG) opens the potential to access the whole Brillouin zone with high time resolution. Time-resolved 2PPE, however, benefits greatly from high repetition rates, whereas harmonics are usually generated at low repetition rates and high intensities.

We present a high-order harmonic source operating with remarkable stability at 100 kHz using a fundamental pulse energy of only 7 μJ. In contrast to earlier perceptions it turns out that high-order harmonics can be efficiently generated even at low pulse energies and thus at high repetition rates [1]. We compare the experimental onditions with theoretical simulations focusing on the characteristics of a tight focus geometry and its consequences for the process of HHG in gases.

[1] F. Lindner *et al.*, Phys. Rev. A. **68**, 013814 (2003)

A 15.4 We 17:15 F 107

Control of attosecond pulse generation using kinetic heterodyne mixing — •Philipp Raith, Christian Ott, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

Tailored attosecond pulses generated by high-order harmonic generation provide coherent access to large-bandwidth electronic spectra and hence the possibility to directly control attosecond quantum dynamics in atoms, molecules and solids. Kinetic heterodyne mixing of a strong laser field with a weak field at a different frequency is an easily realizable method to shape the laser field of the driving femtosecond pulse on a subcycle basis and thus control the generation of attosecond pulses. An experimental design of such a pulse shaper is presented. Performing simulations of the shaped driver pulses and the resulting high-harmonic spectra it is shown how kinetic-heterodyne mixing can be used to generate isolated attosecond pulses. Furthermore, it is analyzed to which extent the spectrum and shape of attosecond pulses can be controlled e.g. to yield higher cutoff photon energies, to control attosecond pulse trains, or to generate very short isolated or double pulses for interferometry applications.

A 15.5 We 17:30 F 107

Towards pump-probe spectroscopy at the yoctosecond time scale — •Jörg Evers[1], Andreas Ipp[1,2], and Christoph H. Keitel[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Institut für Theoretische Physik, Technische Universität Wien, Österreich

For high-precision spectroscopy and structural studies, short light flashes with high photon energy are required. Shorter pulses with higher photon energy would improve the temporal and spatial resolution, or would allow for the investigation of smaller structures, such as for example atomic nuclei. This motivates the search for alternative light sources.

Here, we show that high-energetic photon pulses down to the yoctosecond timescale can be produced in heavy ion collisions [1]. In particular, we focus on light emission from the initial phase of an expanding quark-gluon plasma (QGP). Based on a recent model for the expansion dynamics of the QGP [2], we find that under certain conditions, a double peak structure in the emission envelope can be observed, which could be the first source for pump-probe experiments at the yoctosecond timescale. Finally, we discuss possible detection schemes for short pulses with high photon energy.

[1] A. Ipp, C. H. Keitel, and J. Evers, Phys. Rev. Lett. **103**, 152301 (2009)
[2] M. Martinez and M. Strickland, Phys. Rev. Lett. **100**, 102301 (2008).

A 15.6 We 17:45 F 107

High-order harmonic generation by ultra-short pulses from filamentation — •Daniel S. Steingrube[1,2], Emilia Schulz[1,2], Thomas Binhammer[3], Tobias Vockerodt[1,2], Uwe Morgner[1,2], and Milutin Kovacev[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany — [2]QUEST, Centre for Quantum Engineering and Space-Time Research, Welfengarten 1, Hannover, Germany — [3]VENTEON Laser Technologies GmbH, 30167 Hannover, Germany

High-order harmonics with application to attosecond pulse generation are commonly generated by pulses which are previously compressed in hollow core fibers. An alternative promising scheme for pulse compression is based on filamentation. Therefore, 30-fs-pulses from a commercial amplifier system are focused into a filamentation cell filled with argon. An octave spanning spectrum from 400 to 900 nm is obtained which yields pulses with duration below 7 fs measured with SPIDER. The white light core of the filamented output beam contains an energy of 0.3 mJ.

The compressed pulse is applied for high-order harmonic generation (HHG) which is performed in a semi-infinite gas cell setup after dispersion compensation using double chirped mirrors (DCM). The resulting spectra are presented for different generating gas media as xenon, argon, and neon. The spectra are spectrally broadened compared to those generated by the 30-fs-pulse. Moreover, the cut-off energy of the generated spectra is investigated for different pulse durations which are applied by varying the number of bounces on the DCMs.

A 15.7 We 18:00 F 107

Inducing and Probing Attosecond-Time-Scale Electronic Wavefunction Beating — •Christian Ott, Philipp Raith, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Much of the current interest in the field of ultrafast science focuses on the observation of attosecond dynamics of electronic wavepackets. These experiments typically require attosecond pulses either for pumping or probing such dynamics and/or are limited to observing electronic states embedded in the ionization continuum of atoms. Here, we present numerical evidence – based on solutions of the time-dependent Schrödinger equation for a 1-dimensional model atom – that a pump-probe scheme with two few-cycle femtosecond laser pulses provides interferometric access to sub-femtosecond electron wavepacket dynamics. Both continuum- and bound-state electronic wavepacket interference can be simultaneously observed by recording and analyzing time-delay dependent interferences in the ATI spectrum of an atom. Both dipole-allowed and forbidden electronic transition information can be extracted from the data, making this approach a versatile and comprehensive spectroscopic method for probing the bound electronic level structure of an atom.

A 15.8 We 18:15 F 107

High Harmonic Transient Grating Spectroscopy — •Markus Gühr[1,2], Joseph P. Farrell[1,2], Limor S. Spector[1,2], Brian K. McFarland[1,2], Mette Gaarde[1,3], Kenneth Schafer[1,3], and Philip H. Bucksbaum[1,2] — [1]Stanford PULSE Institute, SLAC National Accelerator Laboratory, Menlo Park, USA — [2]Physics and Applied Physics, Stanford University, USA — [3]Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA 70803, USA

High harmonic generation (HHG) spectra contain valuable information about the electronic structure of the generation medium, information that has proven to be powerful for monitoring molecular and atomic ground states. All HHG experiments on excited atomic or molecular states suffer from a ground state harmonic background, thereby reducing excited state sensitivity. We use a transient grating (TG) scheme to overcome this problem and also obtain spectrally resolved high harmonics without the need for a spectrometer. We imprint a 400 nm excited state grating structure on the HHG medium by two counter-propagating 800 nm pulses. A strongly focused 800 nm probe pulse hits the grating under a shallow angle. The harmonics of order n are scattered into the Bragg angle $\theta_{Bragg} = asin(1/n)$. We test the scheme with plasma gratings in argon gas and molecular alignment gratings in N_2. The generated harmonics are scattered into their respective Bragg angle and we observe up to 6 spectrally resolved harmonics that show enhanced sensitivity to the atomic or molecular excitation.

A 16: Ultra-Cold Atoms: Single Atoms (with Q)

Time: Wednesday 16:30–17:45 Location: A 320

Group Report A 16.1 We 16:30 A 320

Real-time feedback control of a single atom trajectory — •Alexander Kubanek, Markus Koch, Christian Sames, Alexei Ourjoumtsev, Pepijn Pinkse, Karim Murr, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Garching, Germany

Feedback is a general, well developed technique, which provides an important tool to control classical systems in a wide variety of fields. Novel features arise when transferring the idea of feedback into the quantum domain, e.g. to engineer non-trivial quantum states. An interesting question is whether one can influence quantum trajectories by measurement and feedback without violating Heisenberg uncertainty relations. A prerequisite for this is to measure and react in real time with a minimum measurement rate and, hence, disturbance.

By combining the arsenal of cavity QED techniques with blue-light trapping we have now achieved a longstanding goal, namely the real-time feedback control on the motion of a single atom. The feedback acts on a time scale that is 70 times faster than the typical time for the evolution of the centre of mass of the atom. Individual probe photons carrying information about the atomic position activate a dipole laser that steers the atom towards or away from the cavity centre. Depending on the specific implementation, the trapping time is increased by a factor of more than four and the localisation of the atom improved owing to feedback cooling. Such a feedback technique teaches us that one can control an apriori unpredictable atomic trajectory, and marks a step towards the exploration of quantum trajectories.

A. Kubanek, et al., Nature, in press (2009)

A 16.2 We 17:00 A 320

Fokussierung eines Einzelionenstrahls — •W. Schnitzler[1], G. Jacob[1], R. Fickler[2], F. Schmidt-Kaler[1] und K. Singer[1] — [1]Universität Ulm, Institut für Quanteninformationsverarbeitung, Albert-Einstein-Allee 11, D-89069 Ulm, Deutschland — [2]Universität Wien, Institut für Quantenoptik, Quantennanophysik & Quanteninformation, Boltzmanngasse 5, A-1090 Wien, Österreich

Basierend auf einer segmentierten linearen Paul-Falle [1] wurde ein Verfahren entwickelt, welches es ermöglicht, deterministisch eine vorgegebene Anzahl von Ionen zu laden. Diese Ionen werden anschließend deterministisch aus der Falle extrahiert und in einem Abstand von 257 mm in einen Spot mit einem 1σ-Radius von $(4.62 \pm 1.25)\,\mu$m fokussiert [2]. Verglichen mit dem anfänglichen Strahlradius von $83(^{+8}_{-3})\,\mu$m wird der Einzelionenstrahl somit auf 1/18 seiner ursprünglichen Größe verkleinert. Aufgrund der geringen Strahldivergenz und der schmalen Geschwindigkeitsverteilung unserer Einzelionenquelle ist die chromatische und sphärische Aberration an der Einzellinse stark reduziert, was einen vielversprechenden Ausgangspunkt für die Fokussierung einzelner, in ein Substrat zu implantierender Ionen darstellt [3-5]. Ein neuartiges Linsendesign soll die Auflösung noch weiter verbessern und eine Nachbeschleunigung der Ionen auf mehrere keV ermöglichen.

[1] W. Schnitzler *et al.*, Phys. Rev. Lett. **102**, 070501 (2009)
[2] W. Schnitzler *et al.*, quant-ph/0912.1258, submitted to NJP
[3] B. Kane, Nature **393**, 133 (1998)
[4] F. Jelezko *et al.*, Phys. Rev. Lett. **93**, 130501 (2004)
[5] T. Shinada *et al.*, Nature **437**, 1128 (2005)

A 16.3 We 17:15 A 320

Highly efficient, sub microsecond photoionisation detection of single ^{87}Rb atoms — •Florian Henkel[1], Michael Krug[1], Julian Hofmann[1], Wenjamin Rosenfeld[1], Markus Weber[1], and Harald Weinfurter[1,2] — [1]Department für Physik der LMU, Schellingstrasse 4/III, 80799 München — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, 85748 Garching

We experimentally demonstrate a technique suitable for detecting single optically trapped atoms in less than $1\,\mu$s with high efficiency. The scheme is based on hyperfine-state-selective photoionisation of single atoms and subsequent detection of the correlated photoion-electron pairs via two channel electron multipliers. By coincidently counting these single pairs [1], both detectors are calibrated to absolute values, with single detector efficiencies exceeding $\eta_{ele} = (0.875 \pm 0.002)$ and $\eta_{ion} = (0.926 \pm 0.010)$. Moreover, defining both as a joint CEM detector, a single neutral atom detection efficiency of $\eta = (0.991 \pm 0.002)$ within $t = 389.3 \pm 3.6$ ns following an ionisation event is achieved.

The detection scheme has a potential range of fundamental applications such as real-time probing of ultracold ensembles with subpoissonian accuracy, as destructive, single-shot readout unit for atomic qubits or as detector for a loophole-free test of Bell's inequality with a pair of trapped atoms at remote locations [1].

[1] J. Dunworth *et al.*, Rev. Sci. Instrum. **11**, 167 (1940), P. Kwiat *et al.*, Appl. Opt. **33**, 1844 (1994).
[2] T. Campey *et al.*, Phys. Rev. A **74**, 043612-9 (2006), W. Rosenfeld *et al.*, Adv. Sci. Lett. **2**, 469 (2009).

A 16.4 We 17:30 A 320

Feedback-optimierte Operationen mit linearen Ionenkristallen — •Stefan Ulm[1], Johannes F. Eble[1], Peter Zahariev[2], Ferdinand Schmidt-Kaler[1] und Kilian Singer[1] — [1]Universität Ulm, Institut für Quanteninformationsverarbeitung, Albert-Einstein-Allee 11, D-89069 Ulm, Germany — [2]Bulgarian Academy of Science, Institute of Solid State Physics, Tzarigradsko Chaussee Blvd. 72, 1784 Sofia, Bulgaria

Wir berichten von Transportoperationen mit linearen ^{40}Ca^{+}-Kristallen unter Anwendung zeitabhängiger, elektrischer Potentiale [1]. Um die Ionen zu kontrollieren, verwenden wir in unserer Methode die aktuelle Positionsinformation, die wir aus der Fluoreszenz der Ionen erhalten und nicht vorher aus einem Fallenmodel berechnete Spannungsrampen [2]. Wir zeigen, mit Hilfe dieser Rückkopplungstechnik den Transport einer vorher festgelegten Anzahl von Ionen sowie die Trennung und Vereinigung von Ionenkristallen. Die Rückkopplungssteuerung ist ein robustes Schema und gleicht experimentelle Fehler wie Bauungenauigkeiten und statische Aufladungen der Falle aus. Außerdem erlaubt unsere Methode, dass der Rechner eine selbst erlernte Spannungsrampe für den geforderten Prozess erzeugt und damit eine vorgegebene Anzahl von Ionen mit einer Erfolgswahrscheinlichkeit von über 99.8 % zwischen zwei Punkten hin und her transportiert. Dieses Verfahren kann dazu verwendet werden, den Betrieb eines zukünftigen, ionenbasierten Quantencomputers zu vereinfachen.

[1] J. F. Eble *et al.*, quant-ph/0912.2527
[2] M. A. Rowe *et al.*, Quant. Inf. and Comp. 2, 257 (2002)

A 17: Ultra-Cold Atoms, Ions and BEC III (with Q)

Time: Thursday 10:30–12:30 Location: F 303

A 17.1 Th 10:30 F 303

All-Optical Cooling and Diagnostics for Relativistic Ion Beams — •Michael Bussmann[1], Ulrich Schramm[1], Danyal F.A. Winters[2,3], Thomas Walther[4], Gerhard Birkl[4], Christina Dimopoulou[3], Fritz Nolden[3], Markus Steck[3], Bernhard Franzke[3], Christian Novotny[3,5], Christopher Geppert[3,5], Wilfried Nörtershäuser[3,5], Christophor Kozhuharov[3], Thomas Kühl[3], and Thomas Stöhlker[2,3] — [1]Forschungszentrum Dresden-Rossendorf e.V., D-01328 Dresden — [2]Ruprecht-Karls-Universität Heidelberg, D-69120 Heidelberg — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, D-64291 Darmstadt — [4]Technische Universität Darmstadt, D-64289 Darmstadt — [5]Johannes-Gutenberg-Universität Mainz, D-55099 Mainz

Laser cooling of ion beams at relativistic energies at the Experimental Storage Ring (ESR) at GSI has shown that in order to address the complete phase space of an initially hot ion beam, laser systems have to deliver light at a wide range of frequencies. If all ions are cooled by the laser force, the beam momentum spread can be reduced to a level that cannot be resolved by standard accelerator diagnostics. In our talk we introduce new laser systems and optical diagnostics that are currently set up for an upcoming laser cooling experiment at ESR. We discuss the impact of these new developments on the detection of beam ordering referring to laser cooling experiments previously performed at the ESR.

A 17.2 Th 10:45 F 303

Measurements of the Interaction between Ultracold Atoms and Carbon Nanostructures — •Philipp Schneeweiss[1], Michael Gierling[1], Gabriela Visanescu[1], Johannes Märkle[1], Benjamin Jetter[1], Thomas Judd[1], Michael Häffner[1], Dieter Kern[1], Carsten Weiss[2], Reinhold Walser[3], Andreas Günther[1], and József Fortágh[1] — [1]Center for Collective Quantum Phenomena and their Applications, Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen — [2]Institut für Quantenphysik, Universität Ulm, D-89069 Ulm — [3]Institut für Angewandte Physik, TU Darmstadt, Hochschulstraße 4a, D-64289 Darmstadt

We have developed an ultracold atom experiment for studying interactions between Rubidium atoms and carbon nanotubes (CNTs). In a first series of measurements, ultracold atom clouds have been used as a scanning probe for measuring the topography of CNT structures on a chip surface. A magnetic conveyor belt allows the three-dimensional nano-positioning of atomic ensembles above the chip. The method can successfully resolve extended arrays and lines of nanotubes, as well as individual, freestanding CNTs.

In a second experiment, the loss and heating rates of atom clouds spatially overlapping with a single, freestanding CNT have been measured. Using the data, we quantify the total scattering cross-section and compare it to the geometrical cross-section between the atoms and the single CNT. We find first evidence for the influence of Casimir-Polder effects in the interaction and discuss its contributions to the scattering cross-section.

A 17.3 Th 11:00 F 303

Controlling spin dynamics in a one-dimensional quantum gas — •Philipp Wicke, Shannon Whitlock, and Klaasjan van Druten — Van der Waals-Zeeman Institute, University of Amsterdam, The Netherlands

Reducing the dimensionality of a system has dramatic consequences and leads to remarkable new physics. In this regard, quantum gases offer unique opportunities to address important open questions in quantum many-body physics, by allowing full control over all relevant parameters. We create coherent superpositions of both spin and motional degrees of freedom and probe spin dynamics of a one-dimensional (1D) Bose gas of ^{87}Rb on an atom chip. We observe interaction driven focusing of one spin component by mean field interaction with another component, directly related to the effective 1D interaction strength. We demonstrate experimental control over the 1D interaction strengths through state-selective radio-frequency dressing. The focusing behaviour is altered by tuning the transverse trapping potential in a state-dependent way. This enables, for instance, access to the point of spin-independent interactions where exact quantum many-body solutions are available.

A 17.4 Th 11:15 F 303

Collisions of single ions with ultracold neutral atoms — •Stefan Schmid[1,2], Arne Härter[1,2], and Johannes Hecker Denschlag[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, Technikerstrasse 25, 6020 Innsbruck, Austria — [2]Institut für Quantenmaterie, Universität Ulm, Albert-Einstein-Allee 45, 89081 Ulm, Germany

We have set up an experiment in which a single trapped Ba^+ ion is immersed into a sea of ultracold neutral Rb atoms.

In the Paul trap we can store single ions as well as strings of several ions cooled to the Doppler limit. We produce our BEC in a QUIC trap and transport it over 30 cm into a linear Paul trap using a moving 1D optical lattice. Subsequently the atoms are loaded into a crossed dipole trap, which is overlapped with the position of the ion.

First experimental results on the collisions of the ion with the ultracold sample are shown.

A 17.5 Th 11:30 F 303

Nonlinear atom interferometer beats classical precision limit — •Eike Nicklas, Christian Gross, Tilman Zibold, Jérôme Estève, and Markus K Oberthaler — Kirchhoff Institute for Physics, University of Heidelberg, Germany

The phase detection precision of classical linear atom interferometers is limited by the standard quantum limit. We report on the realization of a nonlinear atom interferometer based on two hyperfine states of Bose-Einstein condensed Rubidium. The nonlinearity is provided by elastic s-wave collisions and we implemented precision control of the scattering length by employing a narrow Feshbach resonance. In a prototypal measurement with a macroscopic number of atoms we find a precision enhancement of 15% over the standard quantum limit. Within the interferometer a large entangled state with 170 entangled atoms is detected.

A 17.6 Th 11:45 F 303

From single to many particle Rabi oscillations — •Tilman Zibold, Eike Nicklas, Christian Gross, Helmut Strobel, Ion Stroescu, Wolfgang Müssel, and Markus K. Oberthaler — Kirchhoff Institute for Physics, University of Heidelberg, Germany

We experimentally investigate the Josephson dynamics between two weakly coupled spin states in a Bose-Einstein condensate of Rubidium. The relevant parameters of this system are the interaction energy and the tunneling rate. Our system allows for the tuning of the interaction energy by an inter species Feshbach resonance whereas the tunneling rate is controlled by the two photon coupling between the modes. The Josephson dynamics can be divided in three different regimes characterized by the emergence of different dynamics. The adjustability of the system allows us to enter all these three regimes. By measuring atom number imbalance and the corresponding phase we are able to map out phase plane trajectories of all predicted dynamics. The occurrence of self trapped states is further investigated to identify the corresponding bifurcation in the phase plane portrait. The analysis of the small amplitude oscillations with mean phase 0 and pi respectively allows us a precise determination of the interaction energy between the two modes and therefore a characterization of the elastic part of the Feshbach resonance.

A 17.7 Th 12:00 F 303

Preparation of a degenerate mesoscopic sample of fermions — •Friedhelm Serwane[1,2], Timo Ottenstein[1,2], Thomas Lompe[1,2], Gerhardt Zürn[1,2], Martin Ries[1,2], Philipp Simon[1,2], and Selim Jochim[1,2] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Physikalisches Institut, Universität Heidelberg

Systems consisting of only few degenerate interacting fermions have prominent examples in nature: e.g. nuclei in the atomic core. Our goal is the preparation of such a system with tunable properties in the laboratory using ultracold fermionic ^{6}Li atoms. Here, the interaction strength can be tuned over many orders of magnitude by means of a Feshbach resonance.

With the ability to control the number of fermions in the trap, studies of the system's properties in dependence of the atom number n will become possible. One intriguing example is the appearance of many-body effects such as superfluidity. In the extreme limit, the sample consists of only two atoms in different spin states which potentially can be used as a high-fidelity qubit.

To control n precisely, we transfer atoms from a large optical dipole trap into a micron-sized dipole trap with well separated energy levels. By applying a magnetic field gradient, we are able to spill atoms in a controlled way ending up with a highly degenerate Fermi gas. So far we can control the atom number down to 120 atoms, limited by the imaging technique. Also we were able to count single atoms in a MOT with fluorescence imaging. In the next step we will combine these techniques to study smaller samples of highly degenerate fermions.

A 17.8 Th 12:15 F 303

Study of matter-wave speckle patterns — •Nicolas Cherroret[1] and Sergey Skipetrov[2] — [1]Quantum optics and statistics group, Institute of Physics, Albert Ludwigs University of Freiburg, Germany — [2]Laboratoire de Physique et Modélisation des Milieux Condensés, Grenoble, France

The behavior of Bose-Einstein Condensates (BECs) in disordered potentials attracts growing interest of physicists during the last few years. More specifically, the properties of a BEC released from a trap in a random potential has been studied. From the experimental viewpoint, BEC systems are very controllable and versatile, and direct measurements of the atomic spatial density n(r) can be performed. During the last two years, considerable efforts were made to study the ensemble average of n(r) in 1D, 2D, and 3D systems, with special interest in the phenomenon of Anderson localization. In the same time, very few results concern the statistics of n. However, it is well known that a wave propagating in a disordered medium generates a complicated intensity pattern ("speckle") due to multiple scattering from inhomogeneities. Since a weakly interacting BEC can be regarded as a coherent matter wave, an analogous phenomenon should also show up in the case of BECs. We analyze these "matter-wave speckle patterns" theoretically and show that they exhibit long-range density correlations, strongly enhanced at long times, which can even take negative values for sufficiently distant points.

Reference: N. Cherroret and S.E. Skipetrov, Phys. Rev. Lett. 101, 190406 (2008)

A 18: Precision Spectroscopy of Atoms and Ions II

Time: Thursday 10:30–12:45 Location: F 107

A 18.1 Th 10:30 F 107

Laserspektroskopische Messungen an schnellen Ionen für einen Test der Speziellen Relativitätstheorie — •Benjamin Botermann[1], G. Huber[1], S. Karpuk[1], W. Nörtershäuser[1,4], C. Novotny[1], D. Bing[2], D. Schwalm[2], A. Wolf[2], G. Gwinner[3], C. Geppert[1,4], T. Kühl[4], T. Stöhlker[4], T. W. Hänsch[5], S. Reinhardt[5] und G. Saathoff[5] — [1]Johannes Gutenberg Universität Mainz — [2]MPI für Kernphysik, Heidelberg — [3]University of Manitoba, Winnipeg, Canada — [4]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [5]MPI für Quantenoptik, Garching

Durch die Bestimmung der Anregungsfrequenz eines elektromagnetischen Diploübergangs in schnellen Ionen kann die Zeitdilatiation der Speziellen Relativitätstheorie (SRT) mit dopplerfreien Laserspektroskopieverfahren präzise vermessen werden. Für einen Test dieser Art werden im Experimentierspeicherring des GSI Helmholtzzentrums für Schwerionenforschung metastabile $^7Li^+$-Ionen mit einer Geschwindigkeit von 0,338 c_0 gespeichert. In den jüngsten Messungen konnte die Resonanzfrequenz der gespeicherten Lithiumionen auf wenige MHz genau bestimmt und mit der SRT auf einem Niveau von $1,6 \cdot 10^{-8}$ verglichen werden ohne eine Abweichung festzustellen. Damit wurde dieselbe Sensitivität wie bei den Vorgängerexperimenten erreicht, die die SRT bei niedrigeren Ionengeschwindigkeiten getestet haben [1]. Wir stellen Weiterentwicklungen im Experimentaufbau vor, von denen wir erwarten, dass sie die Empfindlichkeit auf Abweichungen von der SRT um eine Größenordnung steigern können.

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

A 18.2 Th 10:45 F 107

Recent theoretical progress in studying the two–photon emission from heavy, few–electron ions — •Filippo Fratini[1,2], Thorsten Jahrsetz[2], Thomas Stöhlker[1,2], Stephan Fritzsche[1,3], and Andrey Surzhykov[1,2] — [1]GSI Helmotholtzzentrum für Schwerionenforschung, D-64291 Darmstadt, Germany — [2]Physikalisches Institut, Universität Heidelberg, D-69120 Heidelberg, Germany — [3]Department of Physical Sciences, P.O. Box 3000, Fin-90014 University of Oulu, Finland

In this presentation we review the recent theoretical progress in studying the two–photon decay of few–electron ions. Special emphasis is placed on the quantum and classical correlations between the emitted photons. We argue that these correlations are described most naturally within the framework of the second–order perturbation theory and the density matrix approach. The general properties of the two–photon (spin) density matrix will be discussed both, in the non–relativistic dipole and exact relativistic approximations. By using these approximations, detailed calculations are performed for the angular and polarization correlations in the $2s_{1/2} \to 1s_{1/2}$ as well as $2^1S_0 \to 1^1S_0$, $2^3P_0 \to 1^1S_0$ and $2^3S_1 \to 1^1S_0$ transitions in hydrogen– and helium–like ions, correspondingly [1]. Based on the results of these calculations, we discuss the role of relativistic and many–body effects in the correlated two–photon emission from heavy atomic systems.

[1] Th. Jahrsetz *et. al.*, poster, this conference.

A 18.3 Th 11:00 F 107

Laser spectroscopy of highly charged argon at the Heidelberg electron beam ion trap — •Volkhard Mäckel, Renee Klawitter, Sven Bernitt, Günter Brenner, José Ramón Crespo López-Urrutia, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

We report on a laser fluorescence measurement of the forbidden visible transition in boron-like Ar^{13+} at the Heidelberg Electron Beam Ion Trap. The M1 $1s^22s^22p\ ^3P_{3/2} - {}^3P_{1/2}$ transition was resonantly excited using a tunable pulsed dye laser while simultaneously monitoring the fluorescence photons, yielding a wavelength of 441.2560(3) nm. Furthermore, by applying forced evaporative cooling on the trapped ions we were able to resolve the Zeeman splitting of the transition due to the magnetic field used for trapping the ions with a resolving power of $\lambda/\delta\lambda$=15000. It has to be noted that the present limitation is mainly due to the Doppler width of the trapped ions. Better cooling together with two-photon excitation should allow for further accuracy improvements.

A 18.4 Th 11:15 F 107

XUV frequency comb metrology — •Christoph Gohle[1], Dominik Z. Kandula[2], Tjeerd J. Pinkert[2], Wim Ubachs[2], and Kjeld S.E. Eikema[2] — [1]Ludwig-Maximilians-Universität München, Schellingstrasse 4, 80977 München — [2]Vrije Universiteit Amsterdam, De Boelelaan 1081, 1081HV Amsterdam

We report on an approach to transfer the remarkable precision of comb lasers to the extreme ultraviolet (XUV), a frequency region previously not accessible to these devices. This is demonstrated by direct XUV frequency comb excitation of ^{4}Helium atoms from the $1s^2$ ground state to the 1snp ($n \in \{4, 5\}$) excited states. The required XUV comb at wavelengths below 52 nm is generated by amplification and coherent upconversion by high order harmonic generation (HHG) of a pair of pulses originating from a near-infrared femtosecond frequency comb laser. Signal in the form of stable Ramsey-like fringes with high contrast is observed when the comb laser is scanned over the nP states of helium. This is the first proof that frequency combs survive the HHG process below 100 nm wavelength. The accuracy of the measured XUV frequencies (6 MHz, 10^{-9} relative accuracy) represents an improvement of almost an order of magnitude over previous results, and challenges these as well as current theoretical calculations. As far as we know, this is the first demonstration of an absolute frequency measurement in the XUV spectral range.

A 18.5 Th 11:30 F 107

Magnesium Spektroskopie mit einem blauen Frequenzkamm — •Sascha Reinhardt, Elisabeth Peters, Thomas Udem und Theodor W. Hänsch — Max Planck Institut für Quantenoptik, Garching, Deutschland

Die Verwendung eines Frequenzkamms für eine Zwei-Photon-Spektroskopie hat den Vorteil, dass eine Spektroskopie begrenzt durch die natürliche Linienbreite möglich ist und nichtlineare Prozesse, wie Frequenzverdopplung, deutlich effizienter genutzt werden können, wie es im Experiment gezeigt wird.

Der Zwei-Photonen Übergang $3^1S_0 \to 3^1D_2$ im Magnesiumspektrum wird mit einem blauen Frequenzkamm bei 431 nm angeregt, der über Frequenzverdopplung eines ps-TiSa Laser bei 862 nm erzeugt wird. Die Absolutfrequenz des Übergangs $3^1S_0 \to 3^1D_2$ und die Isotopieverschiebung zwischen ^{24}Mg und ^{26}Mg sind mit einer Unsicherheit von < 1 MHz bestimmt worden und sind damit um zwei Grössenordnungen genauer als bei vorherigen Messungen [1].

[1] G. Risberg, Ark. Fys. **28**, 381 (1965)

A 18.6 Th 11:45 F 107

Entwicklung eines selbstangeregten Einzelionen-Oszillators für das g-Faktor Experiment an hochgeladenen Ionen — •Sven Sturm[1], Klaus Blaum[2], Wolfgang Quint[3], Birgit Schabinger[1] und Anke Wagner[2] — [1]Institut für Physik, Johannes Gutenberg-Universität, 55099 Mainz, Germany — [2]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [3]GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany

Für die hochpräzise Messung des magnetischen Moments des Elektrons gebunden in wasserstoffähnlichem Silizium und Kalzium [1] muss die Spinausrichtung eines einzelnen Ions in einer Penningfalle detektiert werden. Dies ist unter Ausnutzung des kontinuierlichen Stern-Gerlach Effektes [2] möglich, der eine spinabhängige Verschiebung der Axialfrequenz bewirkt. Um diesen Frequenzunterschied in einer minimalen Messzeit detektieren zu können, wurde ein neuartiges Messystem implementiert. Dabei wird das Ion durch Eigenanregung auf Energien deutlich oberhalb des thermischen Gleichgewichtes gebracht, indem ein Teil des detektierten Signals zurückgeführt wird [3]. Die dabei resultierende exponentiell instabile Bewegung wird durch einen digitalen Signalprozessor (DSP) stabilisiert. Gleichzeitig wird das Signal des Ions gemessen und seine Frequenz aus der akkumulierten Phase extrahiert. Die experimentelle Realisierung sowie erste Ergebnisse werden präsentiert.

[1] B. Schabinger *et al.*, J. Phys. Conf. Ser. **163**, 012108 (2009)
[2] G. Werth *et al.*, Adv. Atom. Mol. Opt. Phys. **48**, 191 (2002)
[3] B. D'Urso *et al.*, Phys. Rev. Lett. **94**, 113002 (2005)

A 18.7 Th 12:00 F 107

Der *g*-Faktor des gebundenen Elektrons in mittelschweren Ionen — •Anke Wagner[1], Klaus Blaum[1], Wolfgang Quint[2], Birgit Schabinger[3] und Sven Sturm[3] — [1]MPI für Kernphysik, D-69117 Heidelberg, Germany — [2]GSI Darmstadt, 64291 Darmstadt, Germany — [3]Institut für Physik, Johannes Gutenberg-Universität, 55099 Mainz, 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 von wasserstoffähnlichem Kohlenstoff und Sauerstoff wurde bereits gemessen [1,2]. Da die BS-QED Effekte mit der Kernladungszahl Z zunehmen, ist es geplant als nächstes den g-Faktor von lithium- und wasserstoffähnlichem Silizium und Kalzium zu messen [3]. 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. Die Larmor-Frequenz wird indirekt durch den kontinuierlichen Stern-Gerlach Effekt [4] gemessen. Der momentane Stand des Experiments, sowie erste Ergebnisse, werden präsentiert.

[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 18.8 Th 12:15 F 107

Nachweiselektronik zur Messung der Eigenfrequenzen eines einzelnen Protons in einer Penningfalle — •Andreas Mooser[1], Klaus Blaum[2,3], Holger Kracke[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 direkte Messung des g-Faktors eines einzelnen Protons in einer Penningfalle. Der g-Faktor kann hierbei aus der Zyklotronfrequenz und der Lamorfrequenz, welche an eine weitere Eigenfrequenz gekoppelt wird, bestimmt werden. Zur Messung der Eigenfrequenzen werden hochempfindliche Detektoren, die den Nachweis des einzelnen Protons erlauben, benötigt. Die Nachweise bestehen aus Resonatoren hoher Güte und einer nachfolgenden rauscharmen Verstärkerstufe. Das Signal kann über induzierte Ströme mit diesen Detektoren nachgewiesen werden. Dabei erlaubt es die kryogene Umgebung das Signal/Rausch-Verhältnis zu erhöhen, indem supraleitende toroidale Spulen verwendet werden. Mit den freien Resonatoren wurden Güten von 35000 und 28000 erreicht. Im Vortrag werden die Verstärkerstufe sowie die supraleitenden Resonatoren vorgestellt. Auf Verlustmechanismen in den Resonatoren wird eingegangen.

A 18.9 Th 12:30 F 107

Precise measurement of the Lamb shift in hydrogen-like lead ions with low-temperature microcalorimeters — •S. Kraft-Bermuth[1], V. Andrianov[1], K. Beckert[1], A. Bleile[1], Ch. Chatterjee[1], A. Echler[1], P. Egelhof[1], A. Gumberidze[1], S. Ilieva[1], O. Kiselev[1], C. Kilbourne[2], H.-J. Kluge[1], D. McCammon[3], J. P. Meier[1], R. Reuschl[1], T. Stöhlker[1], and M. Trassinelli[1] — [1]Gesellschaft für Schwerionenforschung, Darmstadt, Germany — [2]NASA/Goddard Space Flight Center, Greenbelt, USA — [3]Department of Physics, University of Wisconsin, Madison, USA

The precise determination of the energy of the Lyman-α energies in hydrogen-like heavy ions provides a sensitive test of quantum electrodynamics in very strong Coulomb fields. We present the final results of the first measurement of the Lyman-α lines of lead ions Pb81+ with a low-temperature microcalorimeter at the Experimental Storage Ring (ESR) at GSI. The prototype detector array consisted of 8 silicon thermistors with Sn and Pb absorbers, for which an average energy resolution of 130 eV was obtained for 59 keV X-rays. The measured energy of the Lyman-α1 line in the emitter frame was E(Ly-α1,Pb81+)=77.937(26) keV, which agrees well with the theoretical prediction. The systematic error is mainly due to uncertainties in the positions of the pixels as well as the width of the gas-jet target. To improve the statistics, a new array with 32 pixels has been equipped; first tests yielded an average energy resolution of 43 eV for 59 keV X-rays. The talk will report on the current status and discuss perspectives for the Lamb shift experiment with the improved performance .

A 19: Ultra-Cold Plasmas and Rydberg System

Time: Thursday 10:30–12:30 Location: B 302

Invited Talk A 19.1 Th 10:30 B 302

Bound by reflection: Binding mechanisms of ultralong range Rydberg molecules — •Weibin Li — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Quantum reflection, as a pure wave phenomenon, involves the reflection of a particle, which would classically be transmitted. For highly excited atoms it is found that this effect can lead to molecular bound states at extremely long range. Recent experiments have provided evidence for the existence of such ultralong-range molecules, arising entirely from low-energy scattering between a Rydberg electron and a nearby ground state atom. Here, I will report on recent calculations of the molecular structure, that account for such collisions in a non-perturbative way. A broad range of molecular lines are identified, and shown to originate from two different sources: a Rydberg trimer formed in a single-photon association and a series of excited dimer states that arise from, thus far, an unexplored mechanism based on internal quantum reflection at a steep potential drop caused by a shape resonance in electron-atom scattering. The theory shows good agreement with previous experiments and allows to assign the majority of molecular lines observed in recently measured spectra of ultralong-range Rydberg molecules.

A 19.2 Th 11:00 B 302

Thermalization of a strongly interacting 1D Rydberg lattice gas — Beatriz Olmos[1], Markus Müller[2], and •Igor Lesanovsky[3] — [1]Instituto 'Carlos I' de Fisica Teorica y Computacional and Departamento de Fisica Atomica, Molecular y Nuclear, Universidad de Granada, Granada, Spain — [2]Institute for Theoretical Physics, University of Innsbruck, and Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, Innsbruck, Austria — [3]School of Physics and Astronomy, The University of Nottingham, Nottingham, UK

When Rydberg states are excited in a dense atomic gas the mean number of excited atoms reaches a stationary value after an initial transient period. We shed light on the origin of this steady state that emerges from a purely coherent evolution of a closed system. To this end we consider a one-dimensional ring lattice, and employ the perfect blockade model, i.e. the simultaneous excitation of Rydberg atoms occupying neighboring sites is forbidden. We derive an equation of motion which governs the system's evolution in excitation number space. This equation possesses a steady state which is strongly localized. Our findings show that this state is to a good accuracy given by the density matrix of the microcanonical ensemble where the corresponding microstates are approximate zero energy eigenstates of the interaction Hamiltonian. We analyze the statistics of the Rydberg atom number count providing expressions for the number of excited Rydberg atoms and the Mandel Q-parameter in equilibrium.

[1] B. Olmos, M. Müller, I. Lesanovsky, arXiv:0907.4420 (2009)

A 19.3 Th 11:15 B 302

Quantum excitation transport in flexible atomic aggregates — •Sebastian Wüster, Cenap Ates, Alexander Eisfeld, and Jan-Michael Rost — Max-Planck-Institut für Physik Komplexer Systeme, Nöthnitzer Strasse 38, 01187 Dresden

Transfer of electronic excitations on chains of atoms or molecules is important in many areas of physics, such as photosynthetic light-harvesting [1] 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 [2]. 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 excitation propagates via dipole-dipole transitions. In the circular scenario, a conical intersection between two Born-Oppenheimer surfaces of the chain's electronic state has a dominating effect on the quantum dynamics. It strongly affects the atomic centre-of-mass motion and thereby decoheres the reduced electronic density matrix. For our investigation we employ both, full quantum mechanical calculations and a mixed quantum-classical surface-hopping method.

[1] R. van Grondelle and V.I. Novoderezhkin, Phys. Chem. Chem. Phys. 8, (2006) 793.

[2] C. Ates, A. Eisfeld and J.M. Rost, New J. Phys. 10 (2008) 045030.

A 19.4 Th 11:30 B 302

Investigating Rydberg-Surface Interactions on an Atom Chip — •Atreju Tauschinsky, Rutger M.T. Thijssen, Shannon Whitlock, N.J. van Druten, H.B. van Linden van den Heuvell, and R.J.C. Spreeuw — Van der Waals-Zeeman Institute, Universiteit van Amsterdam, Amsterdam, The Netherlands

We have prepared an array of ultracold atomic ensembles confined in a 2D-lattice of microtraps on a chip. This system holds great promise as a quantum register, assuming interactions between neighbouring ensembles can be controlled. For this purpose we are studying long-range Rydberg dipole-dipole interactions.

An open question is the influence of nearby surfaces on the properties of Rydberg atoms. We coherently excite interacting Rydberg atoms in an ultracold gas close to the chip and use an electromagnetically induced transparency resonance to probe atom-atom and atom-surface interactions.

Results on the influence of the surface on an ensemble of interacting Rydberg atoms as well as the effects of atom-atom interactions will be presented.

A 19.5 Th 11:45 B 302

High resolution spectra of ultralong-range Rydberg molecules — •Johannes Nipper[1], Vera Bendkowsky[1], Björn Butscher[1], Jonathan Balewski[1], James P. Shaffer[2], Robert Löw[1], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Germany — [2]Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, USA

Ultralong-range Rydberg molecules are bound states of a Rydberg atom with ground state atoms. The binding mechanism relies solely on local Rydberg electron scattering off the perturbing ground state atom, described by a Fermi-like pseudo potential. The bound states show binding length up to 100nm and binding energies of several MHz [1].

We report on experiments showing high resolution spectra of the molecular ground state and vibrationally excited states of the dimers as well as trimer states. The binding energies are reproduced in great precision by a full solution of the electron-atom interaction. While the vibrational ground state is bound by pure s-wave scattering, the binding mechanism for the excited states arises from quantum reflections off a deep potential well due to a p-wave resonance inside the Rydberg electron wavefunction.

Furthermore experiments in electrical fields show a splitting of the molecular line, indication for a rotational substructure of the molecular ground state.

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

A 19.6 Th 12:00 B 302

Controlling Interactions and Optical Properties of Cold Rydberg Gases — •Sevilay Sevincli and Thomas Pohl — Max Planck Institute for the Physics of Complex Systems, Noethnitzer Strasse 38, 01187 Dresden, Germany

The high sensitivity of Rydberg atoms to external fields as well as interactions among them leads to strong a enhancement of optical nonlinearities in ultra-cold Rydberg gases. Here we present a many-body density-matrix approach that allows to describe such problems under EIT conditions. We find a strong influence of both the effects of an external electric field as well as strong van der Waals interactions on the optical response of an ultra-cold Rydberg gas, and determine the corresponding optical nonlinearities.

We, moreover, develop a scheme that enables external control of the atom's van der Waals interactions, and even permits to turn them off, while preserving the high polarizability of the Rydberg state. This in turn is shown to yield a greatly enhanced Kerr coefficient under a highly coherent many-body gas dynamics.

A 19.7 Th 12:15 B 302

Controlled qubit rotation using Rydberg level shifts — •Ulrich Krohn, Richard Abel, Christopher Carr, and Charles Adams — Atomic and Molecular Physics, Durham University, Durham, United Kingdom

We study the transfer of the population between two ground states in ^{87}Rb controlled by an electro-magnetically induced transparency (EIT) resonance. The system used is well described by a four level atom with two ground states coupled by two phase stabilised laser fields [1] to an intermediate state. A Rydberg state is coupled via Ω_r with a detuning δ_r to the intermediate state. With $\Omega_\mathrm{r} = 0$ the population is transported from one ground state to the other by means of a π-Raman pulse. This transfer is blocked if $\Omega_\mathrm{r} \neq 0$, $\delta_\mathrm{r} = 0$ as the two photon resonance is lifted by EIT.

The population transfer can be unblocked by shifting the Rydberg level out of laser resonance using an electric field or the interaction of other Rydberg atoms with the dark state of the EIT resonance [2, 4]. Given a narrow band excitation laser, e.g. [3], this scheme can be used to implement a single site addressability in an optical lattice when replacing the electric field with an electric field gradient.

References

[1] RP Abel, *et al.*, Optics Letters **34**, 3071 (2009)
[2] M Müller, *et al.*, PRL **102**, 170502 (2009)
[3] RP Abel, *et al.*, Appl. Phys. Lett. **94**, 071107 (2009)
[4] JD Pritchard, *et al.*, arXiv:0911.3523v2 (2009)

A 20: Atomic Clusters III (with MO)

Time: Thursday 14:00–16:00 Location: F 303

Invited Talk A 20.1 Th 14:00 F 303

The hydrated electron studied by fs-photoelectron spectroscopy — •Andrea Lübcke, Franziska Buchner, Nadja Heine, Thomas Schultz, and Ingolf Volkmar Hertel — Max-Born-Insitut, Max-Born-Strasse 2A, 12489 Berlin

Despite decades of intensive research, the nature of the hydrated electron (including its dynamic) is still controversially discussed. We use fs-photoelectron spectroscopy of a liquid jet of aqueous NaI solution to gain new insight into this matter. The solvated electron is generated by photodetachment from the iodide anion with UV laser pulses (6.20 eV) via a charge transfer to solvent process. A delayed laser pulse (4.65 eV) is used to probe the evolution of this electron.

For the first time we measured fs-photoelectron spectra of the solvated electron. We observe a quasi-instantaneous increase of the electron signal followed by a rapid shift of the spectrum caused by solvation of the electron. The signal decays on timescales of several hundred ps to ns due to recombination and/or diffusion. The binding energy of the solvated electron in a 100 mmol NaI solution is determined to be 3.3 eV.

Invited Talk A 20.2 Th 14:30 F 303

Surface Quantum Optics: from Casimir-Polder forces to optical near-fields — •Sebastian Slama — Physikalisches Institut, Tübingen, Germany

Surface Quantum Optics is a new field of physics which combines ultracold atoms with solid surfaces. Such systems show very interesting features like for example the occurrence of Casimir Polder forces by which the atoms are typically attracted towards the surface. The attraction between surface and atom is based on the interaction of fluctuating dipoles, which are excited mainly by electric vacuum field fluctuations. Such forces are one of the few examples where the vacuum energy leads to measurable effects and therefore can be used for tests of QED. Measurements of Casimir-like forces have gained enormous interest in the last few years. Our group recently directly measured the Casimir-Polder force in the so-called transition regime. This was achieved by balancing the unknown surface potential with the known dipole potential of an evanescent wave. Such potentials are steep enough to compensate Casimir forces at distances of only a few hundred nanometers from the surface. Even smaller distances could be reached when the optical near-field is enhanced by surface plasmon resonances. These are collective excitations of electrons in a thin metal film on the surface. By structuring the metal film the optical near field can also be shaped in the transverse direction above the surface. This technique allows generating optical nanopotentials for nano-traps and elements for atom-optics on the surface.

A 20.3 Th 15:00 F 303

Characteristics of High Energy Velocity Map Imaging (HEVMI) spectrometer designed to study the Coulomb explosion from clusters. — •Slawomir Skruszewicz, Johannes Passig, Andreas Przystawik, Nguyen Xuan Truong, Josef Tiggesbäumker, and Karl-Heinz Meiwes-Broer — Institut für Physik, Universität Rostock, Universitätsplatz 3,18051 Rostock, Germany

Angular resolved photoelectron spectroscopy is a key method to gain deeper insight into the strong-field photoionization and electron dynamics of complex systems, such as multi-electron atoms, molecules, and clusters. A powerful and direct technique for the simultaneous measurement of the energy and angular distribution of the photoelectrons is offered by Velocity Map Imaging spectrometry [1]. The modified five-electrode HEVMI configuration, designed to resolve photoelectrons with kinetic energy up to 1 keV has been tested using the photoionization of Ne atoms with high energy photons (20 - 600 eV) at DESY DORIS III facility. The experimental results prove the applicability of the system to measure photoelectrons with kinetic energy up to 550 eV and created by a continuous radiation sources. As a first application of the HEVMI spectrometer we present results of experiments performed on Ag clusters exposed to intense fs-laser pulses which show anisotropic photoelectron emission [2].

[1] A. T. J. B. Eppink and D. H. Parker, Rev. Sci. Instr. 68, 3447 (1997).
[2] Th. Fennel et al., Phys. Rev. Lett. 98, 143401 (2007).

A 20.4 Th 15:15 F 303

Untersuchung der Transferionisation und des doppelten Elektroneneinfangs mit Heliumdimeren — •Jasmin Titze[1], Markus Schöffler[2], Nasine Neumann[1], Hong-Keun Kim[1], Florian Trinter[1], Markus Waitz[1], Jörg Voigtsberger[1], Matthias Odenweller[1], Birte Ullrich[1], Robert Wallauer[1], Lutz Foucar[4], Katharina Kreidi[3], Till Jahnke[1], Achim Czasch[1,5], Lothar Ph. H. Schmidt[1], Robert Grisenti[1], Ottmar Jagutzki[1,5], Reinhard Dörner[1] und Horst Schmidt-Böcking[1] — [1]Institut für Kernphysik Frankfurt, Goethe-Universität Frankfurt, Max-von-Laue-Str. 1, 60438 Frankfurt — [2]Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße1, 64291 Darmstadt — [4]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [5]RoentDek Handels GmbH, c/o Institut für Kernphysik, Max-von-Laue-Str. 1, 60438 Frankfurt am Main

Heliumdimere stellen das am weitesten gebundene atomare System dar. Seine Größe ist mit der eines DNA Moleküls vergleichbar. In Stößen mit Alphateilchen bei Projektilenergien von 150 keV/u wurde die Zerfallsdynamik von Heliumdimeren untersucht. Es wurden hierzu zwei Reaktionskanäle gleichzeitig vermessen, der doppelte Elektroneneinfang und die Transferionsation. Als Messtechnik wurde die COLTRIMS-Technik (COLd Target Recoil Ion Momentum Spectroscopy)verwendet. In den Ergebnissen zeigen sich 3 voneinander unterscheidbare Zerfallsprozesse.

A 20.5 Th 15:30 F 303

Steplike intensity threshold behavior in extreme ionization of laser-driven Xe clusters — •Thomas Fennel[1], Tilo Döppner[1], Jan-Philippe Müller[1], Andreas Przystawik[1], Sebastian Göde[1], Josef Tiggesbäumker[1], Karl-Heinz Meiwes-Broer[1], Charles Varin[2], Lora Ramunno[2], and Thomas Brabec[2] — [1]Institute of Physics, University of Rostock, Germay — [2]Department of Physics, University of Ottawa, Canada

Highly charged Xe^{q+} ion generation up to $q = 23$ is observed in Xe_N embedded in helium nanodroplets and exposed to intense femtosecond laser pulses (λ=800 nm). Laser intensity resolved measurements show that the high-q ion generation starts sharply at an unexpectedly low threshold intensity of about 10^{14} W/cm^2. Above threshold, the Xe ion charge spectrum saturates quickly and changes only weakly for higher laser intensities. Good agreement between these observations and a molecular dynamics analysis [1] allows us to identify the mechanisms responsible for the highly charged ion production and the surprising intensity threshold behavior of the ionization process [2]: (i) rapid inner ionization of Xe to high-q states through an EII-avalanche sparked by TI of Xe atoms which is supported by an early plasmon resonance of the He shell and (ii) suppression of charge recombination by resonant heating of the Xe cluster. We find that resonant heating of the Xe cluster is less important for strong inner ionization but is the key to conserving the charge state distribution produced by avalanching.

[1] T. Fennel et al., Phys. Rev. Lett. 99, 233401 (2007)
[2] T. Döppner et al., submitted (2009)

A 20.6 Th 15:45 F 303

Direct observation of fullerene plasmon oscillations in momentum space — •Sanja Korica[1], Burkhard Langer[2], Axel Reinköster[1], Markus Braune[1], and Uwe Becker[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin-Dahlem, Germany — [2]Institut für Chemie und Biochemie, Freie Universität Berlin, Berlin-Dahlem, Germany

An extended spherical object which gives rise to standing wave oscillations is C_{60} [1]. We performed new near threshold measurements for C_{60} in order to reveal the corresponding threshold behavior. The result was a surprise. The extension of the high energetic sinusoidal behavior to lower energies uncovers a phase jump of $\pi/2$ in the plasmon excitation region [2]. By subtraction of the extended regular oscillation from the experimental data we could unfold the oscillatory behavior of the plasmon excitations directly in momentum space for the first time. In addition, after subtraction of the plasmon oscillation the shell thickness dependent beating behavior of the partial cross sections was exhibited much more clearly than demonstrated before. This shows, that Cohen and Fano's formula [3] provides a very good measure for determining the large scale coherent photoionization behavior as prerequisite for the derivation of energetically more restricted kinds of behavior such as the plasmon oscillations exhibited directly in momentum space for the first time here.

[1] Xu Y B, Tan M Q and Becker U, Phys. Rev. Lett. **76**, 3538 (1996).
[2] Scully S W et al., Phys. Rev. Lett. **94**, 65503 (2005).
[3] Cohen H D and Fano U, Phys. Rev. **150**, 30 (1966).

A 21: Interaction with Strong or Short Laser Pulses I

Time: Thursday 14:00–16:00 Location: F 107

Invited Talk A 21.1 Th 14:00 F 107

Acceleration of neutral atoms in strong short pulse laser fields — •Ulli Eichmann — Max Born Institut, D-12489 Berlin, Germany

Kinematic effects on neutral atoms in focused moderate laser fields have been well studied in the past and have led, for example, to the development of optical dipole traps. Here we report on unexpectedly strong kinematic forces on neutral atoms in strong short laser pulses with intensities up to 10^{16}Wcm^{-2}. We oberve accelerations with magnitudes as high as 10^{14} times Earth's gravity, which result in measurable deflection of atoms despite the short laser pulse duration in the range of 40 to 120 femtoseconds. An explanation of our findings can be given in terms of the ponderomotive force acting on the quasi free photoelectron in the focussed laser field. Due to the Coulomb force the electron drags the ionic core until the laser pulse is over and the electron is left in a long lived bound excited state. Our measurements for different atomic species and different laser parameters are in very good agreement with predictions based on this model. Implications of our results for strong field physics and further prospects will be discussed.

A 21.2 Th 14:30 F 107

On the Interference Picture in Molecular Intense-Laser Field Ionization — Yulian V. Vanne and •Alejandro Saenz — AG Moderne Optik, Institut für Physik, Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin

The solution of the complete time-dependent Schrödinger equation describing atoms or even molecules in ultrashort intense laser pulses is still limited to very small systems. In fact, only recently it became possible to describe both electrons of a hydrogen molecule exposed to an intense 800 nm laser pulse. However, these calculations were restricted to a parallel orientation of the molecular axis with respect to the laser field, reducing the dimensionality due to the preserved cylindrical symmetry. For the first time, we have now overcome this limitation and have investigated the alignment dependence of the strong-field ionization of H_2.

This work focuses on two aspects. First, the ratio of parallel to perpendicular ionization yields is calculated and compared to a recent experiment. Second, it is shown that a simple but popular interference picture suggested by a simplified intense-field ionization model, the strong-field approximation formulated in velocity gauge, can be tested with the aid of energy-resolved electron spectra obtained for a parallel and a perpendicular orientation. It is demonstrated that the interference picture is not supported by the full two-electron calculation.

A 21.3 Th 14:45 F 107

Raumaufgelöste Untersuchung der Ionisierung im Fokus hochintensiver Laserpulse — •Martin Schultze[1,2], Boris Bergues[1], Hartmut Schröder[1], Karl-Ludwig Kompa[1] und Ferenc Krausz[1,2] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-strasse 1, 85748 Garching — [2]Ludwig-Maximilians-Universität, Fakultät für Physik, Am Coulombwall 1, 85748 Garching

Wir präsentieren eine neuartige Technik zur räumlich aufgelösten Untersuchung des Ionisierungsverhaltens von Atomen im Fokus hochintensiver Kurzpulslaser. Die Methode unterliegt nicht den Limitierungen der bisherigen experimentellen Methoden die bei der Signalerfassung über ein ausgedehntes Volumen, typischerweise deutlich größer als der Laserfokus, integrieren. Das Messchema erlaubt damit präzisen Einblick in die Entwicklung der Ionisation oberhalb der Sättigungsintensität in einem weitem Intensitätsbereich zwischen dem einsetzen der Ionisierung und relativistischen Intensitäten

A 21.4 Th 15:00 F 107

An adiabatic approximation in time-dependent density functional theory based on ground-state spin-density functional theory — •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

We investigate strong-field ionization of the Helium atom within time-dependent density functional theory with adiabatic exchange correlation (xc) potentials. While simple adiabatic approximations such as the adiabatic local density approximation are known to fail badly for the double ionization process in Helium, it has been demonstrated that the exact adiabatic xc potential is close to the exact xc potential [1]. We report here a new adiabatic method in which the Hartree-xc-potential is obtained as the difference between the adiabatically exact Kohn-Sham potential and the external potential that yields the given density using ground-state exchange-only spin-density functional theory for the interacting system. In contrast to the exact adiabatic potential, our scheme does not require the solution of the interacting two-electron Schrödinger equation. We present results for a model Helium atom.

[1] M. Thiele, E. K. U. Gross, and S. Kümmel, Phys. Rev. Lett. **100**, 153004 (2008).

A 21.5 Th 15:15 F 107

HHG mit einem 2.1 μm Treiberlaser zur effizienten Erzeugung von weicher Röntgentstrahlung — •Wolfram Helml[1], Gilad Marcus[1], Yunpei Deng[1], Xun Gu[1], Reinhard Kienberger[2] und Ferenc Krausz[3] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Deutschland — [2]TU München, Physik-Department E11, James-Franck-Str., 85748 Garching, Deutschland — [3]Ludwig-Maximilians-Universität München, Fakultät für Physik, Am Coulombwall 1, 85748 Garching, Deutschland

Wir benutzen einen selbstgebauten OPCPA-Laser (500 μJ, 17 fs, 1 kHz, CEP-stabilisiert) zur Erzeugung von XUV-Strahlung im Energiebereich des Wasserfensters (283 - 532 eV) und darüber hinaus.

Theoretische Modelle sagen für den Prozess der Erzeugung Hoher Harmonischer (HHG) eine quadratische Zunahme der erreichbaren Photonenenergien mit der Wellenlänge des verwendeten Treiberlasers voraus. Um diese Vorhersage zu überprüfen wird der IR-Laser auf ein mit Edelgas (Ne) gefülltes Nickelröhrchen fokussiert und die erzeugte XUV-Strahlung in Abhängigkeit vom Druck des Gases gemessen.

Wir demonstrieren ein Hochenergie-Plateau, das weit über das Wasserfenster hinausreicht, und deutliche Hinweise darauf, dass der Energieabfall (high-energy cutoff) über die 1 keV-Grenze hinausgeschoben werden kann. Diese kohärenten, hochenergetischen XUV-Strahlen eignen sich ideal um Experimente an lebenden Geweben möglich zu machen und extrem kurze Attosekunden-Pulse für zeitaufgelöste Spektroskopie zur Verfügung zu stellen.

A 21.6 Th 15:30 F 107

Stern-Gerlach type analysis of atoms excited by a strong laser field — •Sebastian Eilzer[1], Thomas Nubbemeyer[1], Karsten Gorling[1], Ulli Eichmann[1,2], and Wolfgang Sandner[1,2] — [1]Max-Born-Institut for Nonlinear Optics und Short Pulse Spectroscopy, Berlin, Germany — [2]TU Berlin, Institut für Optik und Atomare Physik, Germany

Excitation of neutral atoms in strong laser fields in the tunnelling regime has recently been investigated [1]. A quantitative explanation of the process has been achieved by considering the ionic Coulomb potential in the three step model [2], which allows for bound trajectories. Based on the direct detection of excited neutral atoms we started a series of Stern-Gerlach type experiments. We placed emphasis on revealing possible spin effects in the interaction with the magnetic component of the strong laser field. We will discuss first experimental results.

[1] Nubbemeyer et al. PRL101 233001(2008)
[2] P.B.Corkum, PRL 71, 1994 (1993)

A 21.7 Th 15:45 F 107

The Rescattering Effect in Strong-Field Photodetachment of Negative Ions. — •Boris Bergues[1,2], Hannes Hultgren[1], Igor Kiyan[1], Azra Gazibegović-Busuladžić[3], Dejan Milošević[3,4], and Wilhelm Becker[4] — [1]Albert-Ludwigs-Universität, Freiburg, Germany. — [2]Max-Planck-Institut für Quantenoptik, Garching, Germany. — [3]University of Sarajevo, Sarajevo, Bosnia and Herzegovina. — [4]Max-Born-Institut, Berlin, Germany.

We present experimental and theoretical results on photodetachment of negative ions in strong laser fields. Since in a negative ion the outer electron is bound to the atomic core by a short-range potential, such a system is best suited to verify predictions of Keldysh-Faisal-Reiss (KFR)-like theories. In our previous studies on F^- using linearly as well as circularly polarized light, we showed that the KFR theory for direct electrons quantitatively describes all the features of the measured potodetachment spectra. In the present work we expose Br^- to strong infrared laser pulses of linear polarization. The angle-resolved spectrum of photoelectrons is recorded using an electron imaging technique. The observed photoelectron spectra exhibit a high-energy plateau along the laser polarization direction, which is not described by the KFR-theory for direct electrons. In contrast, predictions of the rescattering theory are in very good agreement with the measured data. This fact enables us to assign the origin of the observed plateau to the rescattering effect. Our findings represent the first observation of electron rescattering in above-threshold photodetachment of an atomic system with a short-range potential.

A 22: Cold Molecules (with MO)

Time: Thursday 14:00–15:00 Location: F 142

A 22.1 Th 14:00 F 142

Exploring the Rb_2 $^3\Sigma_u$ electronic ground state potential — •Christoph Strauss[1], Tetsu Takekoshi[2], Florian Lang[2], Eberhard Tiemann[3], Rudolf Grimm[2,4], and Johannes Hecker Denschlag[1,2] — [1]Institut für Quantenmaterie der Universität Ulm, D-89081 Ulm, Germany — [2]Institut für Experimentalphysik und Zentrum für Quantenphysik, Universität Innsbruck, A-6020 Innsbruck, Austria — [3]Gottfried Wilhelm Leibniz Universität Hannover, D-30167 Hannover, Germany — [4]Institut für Quantenoptik und Quanteninformation der Österreichischen Akademie der Wissenschaften, A-6020 Innsbruck, Austria

The production of ultracold molecules opens up new possibilities for precision spectroscopy. For alkali dimers, triplet states are of special interest, since they are not easily accessible in conventional setups. In our experiments we investigate the triplet $^3\Sigma_u(5S_{1/2} + 5S_{1/2})$ electronic ground state potential, mapping out in detail the vibrational, rotational, hyperfine and Zeeman structure with an absolute accuracy of about 30 MHz. Starting with a sample of $3\text{x}10^4$ ultracold Rb_2 Feshbach molecules in an optical lattice we use optical Raman transitions to couple to the unknown levels. Molecular properties like magnetic moments, rotational and vibrational constants are extracted. In addition, it was also possible to directly observe deeply bound states which consist of a singlet-triplet mixture. After adjusting a few model parameters, the measurements are in general in excellent agreement with calculations. These results will be relevant for future experiments with ultracold Rb_2 molecules, e.g. cold collisions and molecular BEC.

A 22.2 Th 14:15 F 142

High resolution spectroscopy of excited Rb_2 molecules — •Christoph Strauss[1], Tetsu Takekoshi[2], Florian Lang[2], Marius Lysebo[3], Leif Veseth[3], Eberhard Tiemann[4], Rudolf Grimm[2,5], and Johannes Hecker Denschlag[1,2] — [1]Institut für Quantenmaterie der Universität Ulm, D-89081 Ulm, Germany — [2]Institut für Experimentalphysik und Zentrum für Quantenphysik, Universität Innsbruck, A-6020 Innsbruck, Austria — [3]AlbaNova University Center Atomic-Molecular Physics S-106 91 Stockholm Sweden — [4]Gottfried Wilhelm Leibniz Universität Hannover, D-30167 Hannover, Germany — [5]Institut für Quantenoptik und Quanteninformation der Österreichischen Akademie der Wissenschaften, A-6020 Innsbruck, Austria

Even today, understanding the hyperfine structure of excited alkali dimers can be quite a challenge. We carry out precision spectroscopy on excited ultracold Rb_2 molecules which are deeply bound in the $^3\Sigma_g(5S_{1/2}+5P_{1/2})$ triplet potential. By irradiating a sample of $3\text{x}10^4$ Rb_2 Feshbach molecules in an optical lattice with a widely tunable laser we detect excited bound levels through molecular loss. We fully resolve vibrational, rotational, hyperfine, and Zeeman structure. Using a model calculation a large fraction of the observed lines can be attributed to specific states and quantum numbers. However, for higher rotational quantum numbers systematic deviations occur which cannot be explained yet. A good understanding of the molecular structure is important for an optimized population transfer in various deeply bound states. Our results call for further research in this direction.

A 22.3 Th 14:30 F 142

Photoassociative creation of ^{6}Li-^{40}K molecules in a magneto-optical trap — •Armin Ridinger, Saptarishi Chaudhuri, Thomas Salez, Ulrich Eismann, Frédéric Chevy, and Christophe Salomon — Ecole Normale Supérieure, 24, rue Lhomond, 75005 Paris, France

The recent realization of gases of ultra-cold molecules in their vibrational ground state has opened a new frontier in atomic physics. However, efficient atom-molecule conversion by photoassociation (PA) requires a precise knowledge of the molecular potential under study. In this talk I will report on a preliminary study of photoassociation spectroscopy of ^{6}Li- ^{40}K in a magneto-optical trap. In particular we observed more than 40 clearly resolved rovibrational levels of the electronically excited LiK-molecule within 350 GHz below the $4^2P_{3/2}$ atomic limit of ^{40}K allowing for an accurate determination of the interatomic potential parameters.

A 22.4 Th 14:45 F 142

Electric trapping of molecules in a microstructured trap — •Martin Zeppenfeld[1], Barbara G.U. Englert[1], Manuel Mielenz[1], Christian Sommer[1], Josef Bayerl[1], Michael Motsch[1], Pepijn W.H. Pinkse[1,2], and Gerhard Rempe[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — [2]Mesa+ Institute for Nanotechnology, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands

Optoelectrical cooling [1] is possibly the most promising method to produce sub-mK samples of a wide range of polar molecules. Here, we present the experimental realization of a key element of this scheme, a suitable electric trap for molecules. Such a trap must not only provide long lifetimes, but must also provide regions of variable homogeneous electric field to allow the required addressing of transitions between individual rotational M sublevels. In addition to cooling, such a trap might be used for precision Stark spectroscopy of trapped molecules as well as for investigation of cold collisions.

[1] M. Zeppenfeld et al., Phys. Rev. A **80**, 041401(R) (2009)

A 23: Poster II

Time: Thursday 16:30–19:00 Location: Lichthof

A 23.1 Th 16:30 Lichthof

Strong field ionization, drift and rescattering in extreme ultraviolet laser pulses in the stabilization regime — •Hossein Ebadi, Christoph H. Keitel, and Karen Hatsagortsyan — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The strong field ionization dynamics of an atom in a strong extreme-ultraviolet radiation field is investigated using numerical solutions of the time-dependent Schrödinger equation. We show new features of the electron above-threshold ionization (ATI) spectra in the stabilization regime. The phase space analysis of the electron distribution after the interaction allows us to identify the rescattering electron's contribution in the high energy ATI spectra. The latter is different from the well-known rescattering plateau in the case of infrared driving laser field but still explainable in terms of the simpleman model. Moreover, we characterize a rich structure of the electron phase space distribution providing new detailed information on the ionization time evolution. In particular, we demonstrate that the periodic drift of the bound electron wave packet in the highly oscillating field is the reason for periodic bursts of the ionization yield during the interaction. Our findings can be tested in experiments with FLASH laser facility in Hamburg.

A 23.2 Th 16:30 Lichthof

Controlling Two-Electron Threshold Dynamics in Double Photoionization at FLASH — •Michael Schuricke, Gopi Veeravalli, Renate Hubele, Ganjun Zhu, Johannes Albrecht, Jochen Steinmann, Alexander Dorn, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

Controlling the dynamics and understanding the time evolution of correlated many-electron systems is one of the major challenges in physics. Special interest lies in multiple-ionization close to of threshold, where the total kinetic energy available in the final state approaches zero resulting in a strongly correlated system. Thus, in theoretical descriptions all independent particle or self-consistent field approximations fail.

In this regime we investigated the double photoionization (DPI) and ionization-excitation (IE) of state prepared and aligned lithium, from 2 to 12 eV above the DPI threshold ($\hbar\omega$ = 81, 85, 91 eV). Thereby combining three state-of-the-art techniques, namely magneto-optically trapped lithium, a Reaction Microscope and the free-electron laser at Hamburg (FLASH). The total and differential DPI cross sections reveal a strong dependence on the initial state and particularly on the alignment of the 2p-orbital with respect to the VUV-light polarization, whereas no such effect is observed for IE. Approaching threshold the alignment sensitivity increases, which can be understood by attributing these findings to dynamical electron correlations at vanishing excess energy.

A 23.3 Th 16:30 Lichthof

Ein hocheffizientes Elektronen-Ionen-Koinzidenzspektrometer zur zeitaufgelösten Untersuchung der Photoionisation von Atomen und Molekülen im XUV — •Sascha Deinert, Leif Glaser, Markus Ilchen, Frank Scholz, Peter Walter und Jens Viefhaus — Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg

Hochbrilliante Synchrotronstrahlungsquellen der dritten Generation - wie beispielsweise PETRA III - ermöglichen Untersuchungen der Photoionisationsdynamik von Atomen und Molekülen sowohl mit hoher Auflösung, als auch über einen weiten Photonenenergiebereich.

Das hier vorgestellte Elektronen-Ionen-Koinzidenz-Spektrometer ist an den weiten Photonenenergiebereich der PETRA III P04 Variable Polarization XUV Beamline (DESY, Hamburg) angepasst, die Photonen im Energiebereich von 200-3000 eV mit hoher Intensität bei kleinem Bandpass generieren kann. Dadurch können für unterschiedlichste Targets sowohl Photoelektronen als auch Auger-Elektronen mit hoher Energie erzeugt werden. Speziell für den effizienten Elektronennachweis bei hohen kinetischen Energien hat sich dieses sogenannte "magnetic-bottle"-Spektrometer bewährt, welches hier mit einem Flugzeit-Spektrometer für den Ionen-Nachweis kombiniert wird.

A 23.4 Th 16:30 Lichthof

Threshold photoionization in the presence of neutral perturbers — •Jovica Stanojevic and Jan-Michael Rost — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Strasse 38, 01187 Dresden, Germany

We explore the influence of nearby ground-state atoms on the photoionization process in ultracold gases. We implement the Green's function method to account for the effects of interactions with surrounding atoms. For energies just above the photoionization threshold, a simpler almost analytical treatment can be devised. This study could offer an alternative way to investigate collisions at ultralow energies.

A 23.5 Th 16:30 Lichthof

Unexpected low-energy structure of photoelectron spectra in mid-infrared strong laser fields: classical description — •Chengpu Liu and Karen Z. Hatsagortsyan — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

The recent experiment by Blaga et al. [Nature Phys. **5**, 335-330 (2009)] on the photoionization of atoms and molecules in strong long wavelength laser fields observes previously unknown low-energy structure (LES) in the energy distribution of electrons emitting along the laser polarization direction. This work is devoted to clarification of the mechanism for the appearance of this LES. We use semiclassical Monte-Carlo simulations and successfully reproduce the experimental results. It is confirmed that the origin of LES involves the influence of the long range Coulomb potential and the forward-scattering of the tunneled electrons which unlike the back-scattering contributes to the low-energy domain. Furthermore, we investigate the scaling of the LES with the Keldysh parameter and its dependence on the atomic binding potential. As the essence of LES is the quasistatic laser assisted scattering of low energy electrons from the atomic core, it is not surprising for LES to be general and present in all atomic and molecular systems.

A 23.6 Th 16:30 Lichthof

Vollständig differentielle Wirkungsquerschnitte der Doppelphotoionisation von Neon bei 165, 440 und 800 eV Photonenenergie — •Markus Waitz[1], Florian Trinter[1], Ute Lenz[1], Christian Stuck[1], Matthew P. Jones[3], Hendrik Sann[1], Hong-Keun Kim[1], Markus S. Schöffler[2], Thorsten Weber[2], Till Jahnke[1], Ottmar Jagutzki[1], Achim Czasch[1], Allen L. Landers[3], Ali Belkacem[2], Mike H. Prior[2], Horst Schmidt-Böcking[1] und Reinhard Dörner[1] — [1]Institut für Kernphysik, Universität Frankfurt, Max-von-Laue Str. 1, D-60438 Frankfurt, Germany — [2]Chemical Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA — [3]Department of Physics, Auburn University, Auburn, Alabama 36849, USA

Mit Hilfe der COLTRIMS-Messtechnik sollte die Photodoppelionisation (PDI) von Neon untersucht werden. An der Advanced Light Source am Lawrence Berkeley National Lab (USA) wurden dazu Messungen mit unterschiedlicher Photonenenergie und -polarisation durchgeführt. Es konnten vollständig differentielle Wirkungsquerschnitte gemessen werden.

A 23.7 Th 16:30 Lichthof

Photoionization of Fe^{14+}: Experimental Absolute Cross-Sections — M. C. Simon[1], •C. Beilmann[1], M. Schwarz[1], S. W. Epp[1], B. L. Schmitt[1], Z. Harman[1,2], T. M. Baumann[1], E. Behar[3], R. Follath[4], O. Schwarzkopf[4], S. Bernitt[1], R. Ginzel[1], S. G. Higgins[1], R. Klawitter[1], K. Kubiček[1], V. Mäckel[1], C. H. Keitel[1], P. H. Mokler[1], G. Reichardt[3], J. Ullrich[1], and J. R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]ExtreMe Matter Institute EMMI, Planckstrasse 1, 64291 Darmstadt, Germany — [3]Technion Israel Institute of Technology, Physics Department, Haifa 32000, Israel — [4]Helmholtz-Zentrum Berlin, BESSY II, Albert-Einstein-Str. 15, 12489 Berlin, Germany

X-ray astrophysics received increasing attention in the last decade, due to the launches of the X-ray observatories *Chandra* and *XMM-Newton*. Photoionization (PI) of highly charged ions (HCIs) plays an important role for the interpretation of the spectra obtained. However, established methods for PI investigations either lack of accuracy or are only applicable to ions in low charge state. We present a novel approch, where the ion cloud of an electron beam ion trap (EBIT) with typical target-ion area densities of 10^{10} ions/cm^2 is exposed to Synchrotron radiation. PI of Fe^{14+} in the photon energy range from 450 to 1100 eV was investigated at BESSY II. A resolving power of up to 6500 and a calibartion limited accuracy of 150 meV were achieved and the feasibility of an absolute cross-section measurement was demonstrated.

A 23.8 Th 16:30 Lichthof

Precision Spectroscopy of Mg^+ Cooling Transitions — •Valentin Batteiger, Maximilian Herrmann, Sebastian Knünz, Guido Saathoff, Theodor W. Hänsch, and Thomas Udem — Max-Planck-Institut für Quantenoptik, Garching, Germany

Precision spectroscopy of dipole allowed transitions in trapped ions is plagued by temperature changes induced by the scanning laser. To circumvent this problem we probe single, sympathetically cooled ions [1]. Final results of an isotope shift measurement on the Mg^+ D1 and D2 line are presented [2], we also discuss a current attempt to infer the upper state lifetime from the lineshape of the ion's fluorescence spectrum. References: [1] M. Herrmann et al., Phys. Rev. Lett. 102, 013006 (2009). [2] V. Batteiger et al., Phys. Rev. A 80, 022503 (2009).

A 23.9 Th 16:30 Lichthof

Experimente zur Zeitdilatation an relativistischen Schwerionen - „Gestern, Heute, Morgen“ — •Christian Novotny[1], D. Bing[2], B. Botermann[1], C. Geppert[1,4], G. Gwinner[3], G. Huber[1], S. Karpuk[1], T. Kühl[4], W. Nörtershäuser[1,4], S. Reinhardt[5], G. Saathoff[5], R. Sanchez[4], D. Schwalm[2], T. Stöhlker[4] und A. Wolf[2] — [1]Johannes Gutenberg Universität Mainz — [2]MPI für Kernphysik, Heidelberg — [3]University of Manitoba, Winnipeg, Canada — [4]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [5]MPI für Quantenoptik, Garching

Seit der ersten direkten Messung der Zeitdilatation von Ives & Stilwell 1938 wurde eine Vielzahl verschiedener Experimente durchgeführt, welche diesen Effekt der Speziellen Relativitätstheorie (SRT) mit kontinuierlich steigender Präzision bestätigen konnten. Gleichzeitig wurden Modelle entwickelt, die Abweichungen von der SRT zulassen und mit dem Quadrat der Teilchengeschwindigkeit skalieren. In unseren Untersuchungen an Lithiumionen in Speicherringen der GSI und des MPIK konnte die Zeitdilatiation bei verschiedenen Ionengeschwindigkeiten auf eine relative Genauigkeit von 10^{-8} bestätigt werden und in kommenden Messungen soll diese Grenze um einen weiteren Faktor 10 verbessert werden. Für zukünftige Zeitdilatationsexperimente bietet der Ausbau der GSI zur FAIR Anlage neue Möglichkeiten. Hier können Ionen bei noch höheren Geschwindigkeiten gespeichert werden, wodurch die Empfindlichkeit, inbesondere für Effekte höherer Ordnung, nochmals gesteigert werden kann.

A 23.10 Th 16:30 Lichthof

Angular and polarisation correlation in the two photon decay of He-like ions — •Thorsten Jahrsetz[1,2], Filippo Fratini[1,2], Andrey Surzhykov[1,2], Thomas Stöhlker[1,2], and Stefan Fritzsche[2,3] — [1]Physikalisches Institut, Heidelberg University, Germany — [2]Gesellschaft für Schwerionenforschung (GSI), Darmstadt, Germany — [3]University of Oulu, Finland

Studies on the two–photon transitions in atomic systems have a long tradition. While, however, investigations in the past dealt mainly with the decay of light atoms and ions, much of today's interest is placed on the high–Z domain. For example, a series of experiments were performed recently at the GSI storage ring to explore the two–photon decay of helium–like uranium U^{90+} ions. Although until now these experiments were restricted to the total and energy–differential rates [1], the photon–photon angular and polarization *correlations* are likely to be observed in the future and will reveal important information on the relativistic, many–body and parity non–conservation phenomena in heavy atomic systems. In this contribution we present a theoretical analysis of the two–photon decay of helium–like ions with special emphasis on angular and polarization correlations between the emitted photons. In order to describe properly such correlations, we apply the density matrix approach and the second–order perturbation theory. Based on this formalism, detailed calculations are performed for the two–photon decay of $2\,^1S_0$, $2\,^3S_1$ and $2\,^3P_0$ states of helium–like xenon Xe^{52+}, gold Au^{77+} and uranium U^{90+} ions.

[1] A. Kumar *et.al.*, Eur. Phys. J Special Topics **169**, 19 (2009).

A 23.11 Th 16:30 Lichthof

Präzisions-Laserspektroskopie an hoch geladenen Ionen in einer Penning-Falle — •Manuel Vogel[1,2], Wolfgang Quint[2], Wilfried Nörtershäuser[2,3] und Richard Thompson[1] — [1]Imperial College London, SW7 2AZ London — [2]GSI, 64291 Darmstadt — [3]Institut für Kernchemie, Universität Mainz, 55099 Mainz

Wir präsentieren experimentelle Techniken zur präzisen laserspektroskopischen Bestimmung der Energien verbotener Übergänge in hoch geladenen Ionen mit relativen Unsicherheiten bis unterhalb des ppb-Bereichs. Dies sind insbesondere Feinstruktur- und Hyperfeinstruktur-Übergänge, die sich im zugänglichen Bereich für Laseranregung befinden. Grundlage ist die Speicherung und Kühlung extern erzeugter Ionen in einer Penning-Falle sowie spezielle Manipulationen der Speicherbewegungen. Die Nachweismethoden sind entweder optisch oder aber rein elektronisch. Vorgesehen sind Messungen der Feinstruktur in leichten bor- und kohlenstoff-artigen Ionen, sowie der Hyperfeinstruktur-Übergänge in schweren, wasserstoff- und lithium-artigen Ionen. Derartige Messungen stellen hochempfindliche Tests theoretischer Vorhersagen im Rahmen der QED gebundener Zustände dar. Sie erlauben zudem eine Messung des magnetischen Moments des Elektrons, sowie des Atomkerns in Abwesenheit diamagnetischer Abschirmung. Die zugehörigen Experimente werden derzeit im Rahmen des HITRAP-Projekts der GSI, Darmstadt, im Rahmen der SPARC-Kollaboration und des Zukunftsprojektes FAIR aufgebaut.

A 23.12 Th 16:30 Lichthof

Precision Laser Spectroscopy of Beryllium — •Rodolfo Sánchez[1,2], Monika Žáková[1], Zoran Andjelkovic[1], Klaus Blaum[3], Mark L. Bissell[4], Gordon W.F. Drake[5], Christopher Geppert[1,2], Magdalena Kowalska[4], Jörg Krämer[1], Andreas Krieger[1], Thomas Neff[2], Rainer Neugart[1], Ferdinand Schmidt-Kaler[6], Dirk Tiedemann[1], Zong-C. Yan[7], Deyan Yordanov[4], Claus Zimmermann[8], and Wilfried Nörtershäuser[1,2] — [1]Universität Mainz, Germany — [2]GSI Darmstadt, Germany — [3]MPI Heidelberg, Germany — [4]CERN, Geneva, Switzerland — [5]University of Windsor, Canada — [6]Universität Ulm, Germany — [7]University of New Brunswick, Canada — [8]Universität Tübingen, Germany

The neutron-rich isotopes of beryllium exhibit a halo structure. Important information of this structure can be obtained by measuring its nuclear charge radius. We have recently performed high-resolution collinear laser spectroscopy on a 30 keV beryllium-ion beam and measured the isotope shifts in the $2\,S_{1/2} \rightarrow 2\,P_{1/2,3/2}$ transitions of $^{7,10,11}Be^+$ with respect to $^9Be^+$. These measurements were combined with high-accuracy atomic theory calculations and the nuclear charge radius of these isotopes was extracted. In this contribution the results of this experiment are presented and further measurements on $^{12}Be^+$, which has about 1000 times smaller production rates as $^{11}Be^+$, are outline.

A 23.13 Th 16:30 Lichthof

Der g-Faktor des gebundenen Elektrons in mittelschweren Ionen — •Birgit Schabinger[1], Klaus Blaum[2], Wolfgang Quint[3], Sven Sturm[1] und Anke Wagner[2] — [1]Institut für Physik, Johannes Gutenberg-Universität, 55099 Mainz, Germany — [2]MPI für Kernphysik, 69117 Heidelberg, Germany — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany

Berechnungen der Quantenelektrodynamik der gebundenen Zustände (BS-QED) lassen sich mit hochpräzisen Messungen des magnetischen Moments des gebundenen Elektrons testen. In der Vergangenheit wurden g-Faktor Experimente an leichten Ionen mit einer relativen Unsicherheit $\delta g/g$ von weniger als 10^{-9} durchgeführt [1]. Der Einfluss der BS-QED nimmt mit der Kernladungszahl zu. Im jetzigen Experiment [2, 3] sollen daher mittelschwere Ionen wie Silizium ($Z = 14$) und Calcium ($Z = 20$) untersucht werden. Die Ionen werden in der Falle mittels einer Mini-EBIS [3,4] erzeugt. In einer Doppel-Penningfalle soll unter Ausnutzung des kontinuierlichen Stern-Gerlach-Effekts die Messung des g-Faktors eines einzelnen Ions erfolgen. Hierzu werden die drei Eigenfrequenzen des Ions (ν_+, ν_- und ν_z) und die Spin-Präzessionsfrequenz (ν_L) gemessen. Die Techniken und erste Ergebnisse an einzelnen Ionen werden vorgestellt.

[1] G. Werth *et al.*, Int. J. Mass Spec. **251**, 152 (2006)
[2] K. Blaum *et al.*, J. Phys. B: At. Mol. Opt. Phys. **42**, 154021 (2009)
[3] B. Schabinger *et al.*, J. Phys. Conf. Ser. **163**, 012108 (2009)
[4] B. Schabinger *et al.*, J. Phys. Conf. Ser. **58**, 121 (2007)

A 23.14 Th 16:30 Lichthof

Online Spectroscoy of Trapped Radium Isotopes — •Oscar O. Versolato, Gouri S. Giri, Joost van den Berg, Duurt Johan van der Hoek, Wilbert Kruithof, Bodhaditya Santra, Praveen Shidling, Lorenz Willmann, Hans W. Wilschut, and Klaus Jungmann — Kernfysisch Versneller Instituut, University of Groningen

Radium ions are of particular interest for a most precise measurement of Atomic Parity Violation. From a single cold and trapped ion one expects a significantly improved measurement of the weak mixing (Weinberg) angle through a determination of the light shift in the forbidden $7^2S_{1/2}$-$6^2D_{3/2}$ transition. In preparation of such precision measurements the transitions relevant for this (7S-7P, 6D-7P) were observed and measured in the isotopes ^{212}Ra, ^{213}Ra and ^{214}Ra. The isotopes were produced at the TRIμP facility of KVI, when a ^{208}Pb beam hit a solid ^{12}C target. The Ra isotopes were stopped and re-ionized to Ra^+ in a Thermal Ionizer, mass separated in a Wien Filter and cooled in a gas filled Radio Frequency Quadrupole. The ions were stored as a cloud in a Paul trap, where they also interacted with laser light. All necessary wavelengths were obtained by semiconductor lasers. The setup and the measurements will be discussed.

A 23.15 Th 16:30 Lichthof

Frequenzkamm-Spektroskopie von Waserstoff bei 205 nm — •Sascha Reinhardt, Elisabeth Peters, Thomas Udem und Theodor W. Hänsch — Max Planck Institut für Quantenoptik, Garching, Deutschland

Wasserstoff als einfachstes Atom ist ein ideales System um Theorie und Experiment zu vergleichen. Die Messungen des 1s-2s Übergangs liefern präzise Werte für die Rydberg-Konstante und Lambverschiebungen. Die Genauigkeit ist mit in einer relativen Unsicherheit von 10^{-14} schwer weiter zu verbessern. Daher sind Messungen von anderen Übergängen im Wasserstoff sinnvoll um die Werte für die Rydberg-Konstante und Lambverschiebung weiter zu verbessern [1]. Ein interessanter Übergang ist der zwei Photonenübergang 1s-3s im Wasserstoff, der mit einer Wellenlänge von 205 nm angeregt werden kann. In dem vorgestellten Experiment wird der prinzipielle Aufbau und Stand vorgetragen, insbesondere wird auf die Erzeugung und Verwendung eines Frequenzkamm bei 205 nm zur Spektroskopie eingegangen [2].

[1] F. Biraben, European Physical Journal-Special Topics **172**, 109 (2009)
[2] E. Peters, S. A. Diddams, P. Fendel, S. Reinhardt, T. W. Hänsch, and Th. Udem, Optics Express **17**, 9183-9190 (2009)

A 23.16 Th 16:30 Lichthof

Investigations of Excitation Processes in Stored Highly Charged Ions — •D. B. Thorn, A. Gumberidze, S. Trotsenko, N. Petridis, R. Grisenti, C. Kozhuharov, G. Weber, U. Spillmann, Th. Stoehlker, A. Surzhykov, D. F. A. Winters, S. Geyer, R. Maertin, M. Trassinelli, D. Banas, D. Yu, W. Chen, N. Winters, R. Reuschl, S. Hess, M. Hegewald, A. Simon, R. Dubois, and H. Beyer — Work performed at GSI-Darmstadt. See poster for Affiliation information.

Electron- and proton-impact excitation (EIE and PIE) of bound electrons are among some of the most fundamental spectral line formation processes in the universe. In highly charged high-Z ions these two processes are in principle similar (a coulomb field excites the electron), except that EIE is characterized by a sharp threshold, which is not present in PIE because of the much larger momentum transfer possible between a proton and an electron. Furthermore, QED is predicted to affect the EIE process while the PIE process is left untouched. Previously, there have been no EIE measurements done at heavy ion storage rings and so all previous experiments were either carried out at electron beam ion trap facilities or fusion plasma facilities. At GSI we have made use of the experimental storage ring (ESR) to make studies of EIE and PIE of *K*-shell transitions in stored hydrogenlike uranium ions during collisions with neutral gas atoms. In this poster we describe a novel approach that utilizes a cryogenically cooled liquid microjet source to differentiate the two processes.

A 23.17 Th 16:30 Lichthof

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

An electron beam ion trap (EBIT) is an effective tool for spectroscopy of highly charged ions (HCIs). However, the deep trapping potential found there can cause high temperatures of the stored ions, thereby limiting the final resolution. To allow for better accuracy we have started building up a linear cryogenic Paul-Trap experiment (CryPTEx) online with an EBIT. Storage times of HCIs could be extended to by orders of magnitude due to the extremely low background pressure which can be achieved in a 4K enclosure. Furthermore, the device allows sympathetic cooling with laser-cooled singly charged ions. Thus, much higher precision in atomic spectroscopy even down to the natural line width of the forbidden transitions of the stored HCIs should be achievable. In addition, addressing individual ions becomes also possible, since these arrange themselves in stable Coulomb crystals.

A 23.18 Th 16:30 Lichthof

Development of a High Current Electron Beam Ion Trap at the MPI-K — •Thomas Baumann, José Crespo López-Urrutia, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, 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 7 T 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 23.19 Th 16:30 Lichthof

Extreme-Ultraviolet Spectroscopy on highly charged Fe Ions in an EBIT — •Thomas Baumann, Guiyun Liang, José Crespo López-Urrutia, Hiro Tawara, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Spectra in the extreme-ultraviolet range between 10 and 35 nm emitted from iron ions in charge states ranging from Fe VIII to Fe XXIV have been observed at the Heidelberg electron beam ion trap (EBIT). The emission spectra were recorded sequentially at electron beam energies from 75 eV up to 3 keV using a high precision flat-field grazing-incidence grating spectrometer.

The spectra clearly show the evolution of each ionic state as a function of the electron energy and, by comparison with collisional-radiative simulations, allow for line identification and separation of blends. Furthermore, the ion charge state distribution within the EBIT plasma could be determined from the relative line intensities. By comparing intensity ratios of emission lines from levels directly populated from the ground state to those starting from metastable levels of Fe XXI and Fe X, the effective electron densities within the plasma under different EBIT operation conditions were extracted.

Thus, EUV spectroscopic measurements serve as a precise tool for EBIT plasma diagnosis, and support solar observations by providing a laboratory technique for line identification.

A 23.20 Th 16:30 Lichthof

Absolute determination of X-ray transition energies in H-like and He-like ions — •Katharina Kubiček, 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 [Rev. Sci. Instrum. 76 (2005), S. 073105] which allows to determine absolute Bragg angles without the need of reference lines. We have reduced further the already small leading experimental uncertainty 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 ΔE < 8 meV are sensitive to the far larger QED contributions of 1 eV.

A 23.21 Th 16:30 Lichthof

Isotope shifts and Hyperfine structure of $^{212-214}$Ra$^+$ — Gouri S. Giri, Bijaya K. Sahoo, Oscar O. Versolato, •Lotje W. Wansbeek, Lorenz Willmann, Hans W. Wilschut, Klaus Jungmann, and Rob G.E. Timmermans — Kernfysisch Versneller Instituut, University of Groningen, Netherlands

The availability of short lived Ra isotopes at the TRIμP facility of the KVI makes the study of atomic structure of these isotopes possible. $^{212-214}$Ra ions are trapped in a buffer-gas filled Paul trap. Isotope shifts and hyperfine structures of $^{212-214}$Ra$^+$ for several transitions were obtained by laser spectroscopy. Ra$^+$ is of particular interest for a most precise measurement of Atomic Parity Violation (APV), currently underway in our group. Such a measurement will provide a stringent test of the Standard Model of particle physics. However, the interpretation of APV measurements require the determination of the weak matrix elements to better than 1% accuracy in order to extract the weak charge (Weinberg angle). Currently, our calculations are accurate to some 3%. We therefore plan to exploit the fact that radium has a wide range of isotopes by looking at the ratio E1APV/ E1'APV for two -or more- isotopes, and thus canceling atomic uncertainties. Here, nuclear structure effects start to play a role. The extracted isotope shifts and hyperfine interactions provide indispensable information. In addition, the measured hyperfine structure of ^{213}Ra$^+$ is of particular interest for the proposed Radium single ion clock.

A 23.22 Th 16:30 Lichthof

Lineare Polarisation des kurzwelligen Endes der Elektron-Kern Bremsstrahlung — •Renate Märtin[1,2], Roman Barday[3], Joachim Enders[3], Yuliya Poltoratska[3], Uwe Spillmann[1], Günter Weber[1,2] und Thomas Stöhlker[1,2] — [1]Gesellschaft für Schwerionenforschung, Darmstadt, Germany — [2]Physikalisches Institut, Universität Heidelberg, Germany — [3]Institut für Kernphysik, TU Darmstadt, Germany

Die Bremsstrahlung ist einer der elementaren radiativen Prozesse in Stößen energiereicher Elektronen mit Materie. Dabei bietet insbesondere das Studium der linearen Polarisation Zugang zur Dynamik von Stoßprozessen geladener Teilchen.

Wir präsentieren vorläufige Ergebnisse zur linearen Polarisation der Bremsstrahlung in Elektron-Atom-Stößen, sowie in Ion-Atom-Stoßprozessen. An der polarisierten Elektronenquelle der TU Darmstadt wurden unterschiedliche Festkörpertargets mit 100 keV Elektronen beschossen. Bei der Messung wurde sowohl die Spineinstellung des Elektronenstrahls als auch die Targetdicke und der Beobachtungswinkel variiert. Zur Messung der linearen Polarisation wurde ein neuartiges Si(Li)-Comptonpolarimeter eingesetzt. Des Weiteren wurde eine Messung der linearen Polarisation der Bremsstrahlung am Gasjet-Target am ESR-Speicherring der GSI durchgeführt. Dabei wechselwirkten hochgeladene Uranionen unterschiedlicher kinetischer Energie mit einem Wasserstoff- bzw. Stickstoffgastarget.

A 23.23 Th 16:30 Lichthof

Towards a Magnesium lattice clock — •Temmo Wübbena[1], André Kulosa[1], Jan Friebe[1], Matthias Riedmann[1], Andre

Pape[1], Hrishikesh Kelkar[1], Sana Amairi[1], Sina Malobabic[1], Steffen Rühmann[1], Ernst-Maria Rasel[1], Wolfgang Ertmer[1], Osama Terra[2], Thorsten Feldmann[2], Burghard Lipphardt[2], Gesine Grosche[2], and Harald Schnatz[2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Physikalisch-Technische Bundesanstalt

Neutral optical lattice clocks have exceeded the stability of microwave atomic clocks. The accuracy of todays best lattice clocks is limited by the shift of the clock transition due to the black body radiation of the atom's environment [1]. To further improve the accuracy of lattice clocks, the applicability of alternative atomic species with lower sensitivity to the black body shift is studied. On this poster we will specify the relevant properties of neutral Magnesium and compare it to the established elements Ytterbium and Strontium as well as to Mercury. We present the current status of the Mg clock experiment including the latest measurements of the Mg clock transitions. We will also describe the necessary steps to realize a Mg lattice clock. Which include the determination of the magic wavelength which is predicted between 420 nm and 470 nm, the setup of an optical lattice and the development of an efficient loading scheme for loading Mg atoms into the lattice.

[1] A. D. Ludlow, et al.: "Sr Lattice Clock at 1×10^{-16} Fractional Uncertainty by Remote Optical Evaluation with a Ca Clock", Science, Vol. 319, p.1804-1808

A 23.24 Th 16:30 Lichthof

Spectroscopy of atomic Radium — •Bodhaditya Santra, Umakanth Dammalapati, Alexander Groot, Klaus Jungmann, and Lorenz Willmann — Kernfysisch Versneller Instituut, University of Groningen, Netherlands

In preparation for a search for a permanent electric dipole moment (EDM) in the heavy alkaline earth element Ra we perform laser spectroscopy to determine energy levels and hyperfine structure splitting. Ra exhibits the largest known atomic enhancement factors for EDMs which violate parity and time reversal symmetries. The intrinsic sensitivity arises from the specific atomic and nuclear structure of Ra. All Ra isotopes with nuclear spin I are radioactive with lifetimes shorter than 15d. Several Ra isotopes are available at the TRIμP facility at KVI. In an effusive atomic beam from an oven containing about 10^{10} ^{225}Ra atoms we performed Doppler-free laser spectroscopy. The $7s^2\ ^1S_0$ - $7s7p\ ^1P_1$ transition at the wavelength 483nm was calibrated against known lines in molecular $^{130}Te_2$. The hyperfine structure splitting was determined to 4196(4) MHz. This transition is best suited for efficient laser cooling of Ra. Furthermore, we build a laser system for magneto optical trapping of Ra on the $7s^2\ ^1S_0$ - $7s7p\ ^3P_1$ intercombination transition at wavelength 714nm based on semiconductor lasers. The setup of the experiment and the results will be discussed.

A 23.25 Th 16:30 Lichthof

Ground state phase diagram of interacting fermions in a disordered 1d optical lattice — •Julia Wernsdorfer[1], Georg Harder[2], Ulrich Schollwoeck[2], and Walter Hofstetter[1] — [1]Institut für Theoretische Physik, Johann Wolfgang Goethe-Universität, Max-von-Laue-Str. 1, 60438 Frankfurt am Main, Deutschland — [2]Department für Physik, Ludwig-Maximilians-Universität München, Theresienstrasse 37, 80333 München, Deutschland

In this work we investigate interacting fermions in a one-dimensional optical lattice with box disorder. Using real-space dynamical mean-field theory [1] the ground state phase diagram is obtained. We quantify localization properties via the probability distribution function of the local density of states and the inverse participation ratio. The accuracy of our results is evaluated by comparison with exact results provided by the density-matrix renormalization group.

[1] M Snoek, I Titvinidze, C Toke, K Byczuk and W Hofstetter, *Antiferromagnetic order of strongly interacting fermions in a trap: real-space dynamical mean-field analysis*, New Journal of Physics **10**, 093008 (2008)

A 23.26 Th 16:30 Lichthof

An interferometrically generated optical bottle beam trap — •Johannes Nipper[1], Siyuan Zhang[2], and Mark Saffman[2] — [1]5. Physikalisches Institut, Universität Stuttgart, Germany — [2]Department of Physics, University of Wisconsin, Madison, WI, USA

We report on a blue detuned optical dipole trap for Cs atoms. Destructive interference of two fundamental Gaussian beams in a Mach-Zehnder interferometer with unequal magnifications in the two arms of the interferometer forms an intensity zero in the focus of the interfered beams, surrounded by regions of higher intensity. This so-called bottle beam creates a trapping potential at moderately high laser intensities, sufficiently deep to trap atoms from a magneto-optical trap. Fast optics with a high numerical aperture forms trap sizes suitable for single atom trapping.

Blue detuned dark traps allow simultaneous trapping of ground state atoms and Rydberg atoms. Furthermore scattering rates and inhomogeneous light shifts due to high light intensities are reduced compared to red dipole traps.

A 23.27 Th 16:30 Lichthof

Strong dipolar effects in Chromium Bose-Einstein condensates — Stefan Mueller, •Jonas Metz, Yong Wan, Ashok Mohapatra, Axel Griesmaier, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart

We present an overview of experimental observations of strong dipolar effects in a Bose-Einstein condensate of chromium. Starting with dipolar interactions which perturb the usual contact interactions, we use a Feshbach resonance to reduce and finally switch off the contact interactions. Investigating the stability diagram of a dipolar gas for various trap shapes we find a universal behaviour in the large N case for all dipolar gases. By inducing a dipolar collapse we study its dynamics and observe the d-wave symmetry of the dipolar interaction in the collapse products. Finally, in order to probe the phase coherence of collapsed condensates, we induce the collapse in several condensates simultaneously and let them interfere.

A 23.28 Th 16:30 Lichthof

Phase diagram of spatially indirect excitons with an effective interaction potential — •Jens Böning, Alexei Filinov, Patrick Ludwig, and Michael Bonitz — Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität, Leibnizstr. 15, D-24098 Kiel, Germany

We derive an effective interaction potential for spatially indirect excitons in quantum well structures [1]. Using this potential and path integral Monte Carlo simulations, we study exciton crystallization and the quantum melting phase transition in a macroscopic system of 2D excitons. Furthermore, the superfluid fraction is calculated as a function of density and is shown to vanish upon crystallization.

[1] A Filinov et al. *J. Phys. A: Math. Theor.* **42**, 214016 (2009)

A 23.29 Th 16:30 Lichthof

Cold gases under influence of spatiotemporal localized pertubations — •Daniel Kotik[1,2], Martina Hentschel[2], and Walter Strunz[1] — [1]Institut für Theoretische Physik, TU Dresden, 01062 Dresden — [2]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 83, 01187 Dresden

Cold atomic gases have attracted a lot of attention in recent years, not least due to the manifold possibilities to manipulate such systems in experiments. On the other hand, many-body effects have been a long research interest in solid-state physics.

Here, we merge both topics and theoretically study the response of dilute, cold atomic gases in a harmonic trap to a spatially localized, sudden perturbation as can be realized by switching on a laser beam. First, we investigate the effect of perturbations of varying strengths, time dependence, and spatial extent in pure bosonic condensates.

We compare this situation with the fermionic case where the many-body response to a sudden, localized potential is known as Anderson orthogonality catastrophe. Furthermore, we study the time-dependence of the perturbation process and will report recent results from simulations on the time evolution in real space.

A 23.30 Th 16:30 Lichthof

Stability and free expansion of a trapped dipolar Fermi gas — •Liang He[1,2] and Su Yi[1] — [1]Institute of theoretical physics, Chinese Academy of Sciences, Beijing, China — [2]Institut für Theoretische Physik, Johann Wolfgang Goethe Universität Frankfurt (Main), Germany

The amazing experimental progress in making degenerate ultracold polar molecules [1] is making ultracold dipolar systems a fascinating research field. For spin polarized ultracold dipolar Fermi gases, the properties of the systems are determined by the dominant dipolar interactions, since the s-wave short-range interactions are strongly suppressed by the Pauli exclusion principle. We investigate the stability of a trapped spin polarized dipolar Fermi gas by a full numerical calculation of the phase space distribution function of the system. We present a stability phase diagram and show that stabilizing the system by tuning the trap geometry is generally inefficient [2]. We further show that the expanded gas always gets stretched along the direction of dipole moment [2, 3].

[1] S. Ospelkaus, A. Pe'er, K.-K. Ni, J. J. Zirbel, B. Neyenhuis, S. Kotochigova, P. S. Julienne, J. Ye, and D. S. Jin, Nature Physics **4**, 622 (2008).

[2] L. He, J.-N. Zhang, Yunbo Zhang,and S. Yi, Phys. Rev. A **77**, 031605(R) (2008).

[3] T. Sogo, L. He, T. Miyakawa, S. Yi, H. Lu, and H. Pu, New J. Phys. **11**, 055017 (2009).

A 23.31 Th 16:30 Lichthof

Stochastic Mean-Field Theory for the Bose-Hubbard Model with Speckle Disorder — •Ulf Bissbort[1], Ronny Thomale[2], and Walter Hofstetter[1] — [1]Institut für Theoretische Physik, Goethe Universität Frankfurt — [2]Department of Physics Princeton University

Using the recently developed stochastic mean-field theory (SMFT) for the disordered Bose-Hubbard model [1], we investigate the phase diagram of interacting bosons with experimentally realistic speckle disorder [2]. In comparison to prototypical box disorder, we find deviations in the phase diagram at low temperature. At fixed density and sufficiently low temperature, we identify parameter regimes at which disorder-induced superfluidity and multiple reentrant behavior is predicted. Our results at finite temperature explain the absence of this phenomenon in recent experiments. In addition to pure on-site disorder, we furthermore include uncorrelated off-diagonal disorder in the hopping energies within the SMFT formalism. To account for effects of the trapping potential and allow for a quantitative comparison with experiments, we also present results of a SMFT + LDA calculation.

[1] U. Bissbort and W. Hofstetter, EPL **86** 50007 (2009).
[2] M. White et al., Phys. Rev. Lett. **102**, 055301 (2009).

A 23.32 Th 16:30 Lichthof

Real-space Dynamical Mean-Field Theory For an Inhomogeneous Bose-Bose Mixture — •Yongqiang Li, Mohammad Reza Bakhtiari, and Walter Hofstetter — Institut für Theoretische Physik , Frankfurt am Main, Germany

Motivated by recent experiments on Bose-Bose mixtures (e.g [1]), we theoretically investigate a two-component Bose-Hubbard model. We consider such a mixture both in two and three dimensional cubic optical lattices, in the presence of an external confining potential. In order to study this inhomogeneous many-body system, we develop a real-space Bosonic Dynamical Mean-Field Theory (R-BDMFT) [2] which is capable of accurately describing the model over a wide range of parameters. For various total filling of both species, we obtain spin-resolved density distributions and more importantly different spin orders including Mott insulator, XY-ferromagnet and XY-superfluid. When each species is at filling one, we determine the phase diagram which shows a second order phase transition from XY-ferromagnet to a Mott insulator and a first order phase transition from XY-ferromagnet to a one-component superfluid state.

[1] J. Catani et al., Phys. Rev. A 77,011603(R) (2008) [2] A. Hubener. M. Snoek and W. Hofstetter, arXiv:0902.2212

A 23.33 Th 16:30 Lichthof

Three-dimensional Rotons and Supersolids in Rydberg-BECs — •Nils Henkel, Rejish Nath, and Thomas Pohl — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

We study properties of Bose Einstein condensates, in which atoms are optically coupled to highly excited Rydberg states, featuring strong van der Waals interactions. This procedure leads to effective ground-state interactions, whose shape can be widely tuned through the applied laser parameters. The special form of the resulting interaction potential is shown to result in a Roton-Maxon type dispersion relation in stable three-dimensional condensates, and to ultimately induce a transition to a supersolid groundstate. We present a theoretical as well as a numerical approach and find excellent agreement between them. Our results indicate that the Roton instability occurs for realistic laser parameters, suggesting that formation of self-assembled supersolids is feasible in current cold atom experiments.

A 23.34 Th 16:30 Lichthof

Ultracold Atoms near Superconductors — •Florian Jessen, Daniel Cano, Helge Hattermann, Max Kahmann, Dieter Kölle, Reinhold Kleiner, and József Fortágh — Center for Collective Quantum Phenomena and their Applications, Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen

Hybrid quantum systems, which combine ultra-cold atoms with solid state devices, have attracted considerable attention in the last few years. Promising applications are in the areas of precision sensing and quantum information processing. We report on our experimental efforts towards the realization of such systems based on ultracold atoms and superconductors. The experiment consists of a rubidium BEC apparatus and a thermally shielded helium flow cryostat at 4.2 K in the same ultrahigh vacuum system. Atom clouds are loaded into a magnetic microtrap formed near a superconducting niobium microstructure. We observe the impact of the Meissner effect on the trap parameters and measure the spin coherence of atoms near the superconductor. The measured coherence times are the longest yet observed in the vicinity of a highly conducting material and confirm the suppression of Johnson noise in superconductors. The results have implications for the development of coherently coupled cold atom/solid state quantum devices, in which cold atoms serve as long term quantum memory.

A 23.35 Th 16:30 Lichthof

BEC quantum carpets — •Andrey Zhukov[1], Wolfgang Schleich[1], and Enio Arimondo[2] — [1]Ulm University, Ulm, Germany — [2]University of Pisa, Pisa, Italy

The phenomenon of matter wave interference of the BEC in a tilted optical lattice was studied. With the help of theoretical model we describe the emerging interference pattern and achieve good agreement with the experimental data as well as with a numerical simulation.

A 23.36 Th 16:30 Lichthof

The thermal Bose gas - a stochastic approach — •Sigmund Heller and Walter T. Strunz — TU Dresden

Temperature dependent quantities like spatial correlation functions [1,2] density fluctuations [3] and interference contrast [4] are measured in current experiments with ultracold Bose gases. In order to describe these experiments, we present a novel stochastic evolution equation which enables us to obtain the thermal state of the canonical ensemble. The equation provides a full quantum field description and therefore does not suffer from cutoff problems which often occur for classical field equations. Furthermore, it is possible to solve the equation in position space - no knowledge of eigenfunctions or eigenenergies of the external potential is required. The equation is derived for the non interacting case, but drawing on analogies with the classical case, it is more than tempting to include the interaction in a mean field sense. Apart from exact results that we obtain for the ideal gas case, we show calculations for an interacting gas in one and three dimensions and obtain good agreement with experimental [2] and theoretical [5,6] work. Results for ground state occupancy, spatial correlation functions and equilibrium density profiles are presented.

[1] I. Bloch et al., Nature 403, 166 (2000).
[2] S. Hofferberth et al., Nature 4, 489-495 (2008).
[3] J. Esteve et al., Phys. Rev. Lett. 96, 130403 (2006).
[4] R. Gati et al., Phys. Rev. Lett. 96, 130404 (2006).
[5]S. Giogini et al., Phys. Rev. A 54, 4633 (1996).
[6] A. Imambekov et al., Phys Rev. A 80, 033604 (2009).

A 23.37 Th 16:30 Lichthof

Atomic mixtures with inelastic scattering — •Eder Santana Annibale, Oleksandr Fialko, and Klaus Ziegler — Universität Augsburg, Augsburg, Deutschland

The interaction of heavy atoms in a Mott state and light spin-1/2 fermionic atoms is studied in a double well potential. Inelastic scattering processes between both atomic species excite the heavy atoms and renormalize the tunneling rate (so called polaronic effect) as well as the interaction of the light atoms. An effective Hamiltonian for the latter is presented, wich describes tunneling of single fermions, tunneling of fermionic pairs and an exchange of fermionic spins. We study the dynamics of quantum states, which enables us to detect the signature of a first order phase transition between Néel and dimer states, as well as the polaronic effect.

A 23.38 Th 16:30 Lichthof

Storing the polarisation state of light in a BEC — •Chris Vo, Matthias Lettner, Stefan Riedl, Dominik Bauer, Simon Baur, Stephan Dürr, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Garching

The polarisation of light is a much used workhorse in quantum cryptography and quantum information applications. We experimentally realise a coherent memory for the polarisation of a light pulse using a Bose-Einstein condensate of ^{87}Rb atoms. Employing electromagnetically induced transparency we can store and retrieve two orthogonal polarisations of a weak probe pulse at the same time. The relative phase of these polarisations is maintained during this procedure. Therefore arbitrary coherent superpositions of these polarisations are stored in our memory. The maximum fraction of the retrieved light power lies above 30%. When storing linearly polarised light the ellipticity of the retrieved polarisation exceeds 80%. We demonstrated 5×10^4 storage and retrieval cycles on a single BEC containing $\approx 10^6$ atoms initially. The number of cycles is limited by heating and loss of atoms induced by the control light. In future experiments this technique could be applied to single photon pulses, realising a quantum memory for the photon polarisation.

A 23.39 Th 16:30 Lichthof

2D flow of a strongly interacting Bose-Einstein condensate — •Eder Santana Annibale — Universität Augsburg, Augsburg, Deutschland

The dynamics of a dilute Bose-Einstein condensate (BEC) can be described to a good approximation by the Gross-Pitaevskii equation (GP). On the other hand, the slave-boson model (SB) has been shown very useful to describe a strongly interacting BEC. In this work we study the dynamics (free expansion) of a strongly interacting BEC using the SB model, in particular the generation of shock waves past an obstacle. This problem was considered using the GP, where it was shown the generation of oblique dark solitons and linear waves. Here, we intend to understand the role of the nonlinearity in the SB for the generation of shock waves.

A 23.40 Th 16:30 Lichthof

Ratchet effect in driven Bose-Einstein condensates — •Martin Heimsoth, Charles Edward Creffield, and Fernando Sols — Facultad de Ciencias Fisicas, Universidad Complutense de Madrid

The generation of a particle current by exposing the system to an unbiased asymmetric periodic driving field is known as the ratchet effect. We demonstrate numerically that a current of a Bose-Einstein condensate whose motion is effectively restricted to a torus can be produced via a driving field with broken spatiotemporal symmetries. We explore the strong driving regime beyond the results presented in Ref [1]. Furthermore, we present a comparison of our numerical results with a recent experimental realization [2].

[1] C.E. Creffield, F. Sols, Phys. Rev. Lett. **103** (2009)
[2] T. Salger et al, Science **326** (2009)

A 23.41 Th 16:30 Lichthof

Nonlinear dynamics of a driven ultracold Bose gas — •Holger Hauptmann, Sigmund Heller, and Walter T. Strunz — Institut für Theoretische Physik, Technische Universität Dresden, Deutschland

We investigate collective modes of ultracold interacting Bose gases in a harmonic potential with a periodic time-dependent perturbation. Comparisons between the full numerics of the Gross-Pitaevskii equation and analytical approximations for the width of the gas cloud are presented. These are valid either in the Thomas-Fermi limit or near the ideal gas limit. For long time propagation the existence of a saddle point of the stroboscopic map in phase space leads to rich and unexpected dynamics.

A 23.42 Th 16:30 Lichthof

Ein Diodenlasersystem für die Atominterferometrie mit zwei Spezies — Jonas Hartwig, Vyacheslav Lebedev, Ernst M. Rasel, Dennis Schlippert, Ulrich Velte, •Nils Winter und Maic Zaiser — Universität Hannover, Welfengarten 1, 30167 Hannover

Wir stellen ein Diodenlasersystem zum simultanen Kühlen und Fangen von Kalium und Rubidium sowie zur Anregung kohärenter Raman-Übergänge für die Atominterferometrie vor. Das Lasersystem zeichnet sich durch sehr gute spektrale Eigenschaften und Stabilität, sowie eine hohe Ausgangsleistung von bis zu 5 W aus. Es wurde modular aufgebaut, um Kompaktheit und Transportabilität bei größstmöglicher Flexibilität zu gewährleisten. Es besteht aus zwei Referenzlasermodulen mit jeweils einem Linearresonatordiodenlaser bei den Wellenlängen 767 nm (K) bzw. 780 nm (Rb), die mittels Frequenzmodulationsspektroskopie auf die jeweilige D2-Linie von K bzw. Rb stabilisiert werden, einem Masterlasermodul dessen Laser mittels Schwebungsmessung frequenz- bzw. phasenstabilisiert werden, sowie einem Verstärkermodul in dem das Licht in mehreren Trapezverstärkern verstärkt wird. Dieser Aufbau ermöglicht eine Verstimmung der Laser um mehrere GHz innerhalb weniger Millisekunden, so dass die Laser sowohl als Rückpumper und Kühler in einer MOT, als auch zum Treiben von Raman-Übergängen eingesetzt werden können. Das vorgestellte Lasersystem soll in Zukunft zur Erzeugung quantenentarteter Bose-Fermi-Mischungen als Quelle für die Atominterferometrie benutzt werden und bildet einen wichtigen Bestandteil für den im Rahmen der Exzellenzinitiative QUEST geplanten Test des Äquivalenzprinzips.

A 23.43 Th 16:30 Lichthof

Measurements of the topography of Carbon Nanotube structures and cold atom-nanotube interactions — •Michael Gierling[1], Philipp Schneeweiss[1], Gabriela Visanescu[1], Johannes Märkle[1], Thomas Judd[1], Michael Häffner[1], Dieter Kern[1], Carsten Weiss[2], Reinhold Walser[3], Andreas Günther[1], and and József Fortágh[1] — [1]Center for Collective Quantum Phenomena and their Applications, Universität Tübingen, Auf der Morgenstelle 14, D- 72076 Tübingen — [2]Institut für Quantenphysik, Universität Ulm, D-89069 Ulm — [3]Institut für Angewandte Physik, TU Darmstadt, Hochschulstraße 4a, D-64289 Darmstadt

We have developed an ultracold atom experiment for studying the interaction between ^{87}Rb atoms and carbon nanotubes (CNTs). We present the setup and the technique that is used for measuring the topography of CNT structures on a chip surface. For the measurements, ultracold atom clouds are used as a scanning surface probe. For the three-dimensional nano-positioning of the atom cloud we use a magnetic conveyor belt. The method allows the resolution of nanotube arrays, nanotube lines, and individual free standing nanotubes. We also present the measurement of loss and heating rates of atom clouds spatially overlapping with a single, free standing CNT. We discuss the acquired data and the possibility to quantitatively describe the interaction between atoms and nanotubes.

A 23.44 Th 16:30 Lichthof

Transition to equilibrium for an interacting Bose gas — •Lena Simon und Walter T. Strunz — Institut für theoretische Physik, TU Dresden, Dresden

We aim to shed light on the transition from a nonequilibrium to an equilibrium state of an interacting quantum many-body system. By solving the full (unitary) Schrödinger equation for a Bose-Hubbard-type model, we investigate the dynamics of the one-particle-density operator. We present fully numerical results and aim to elucidate the irreversible transition to equilibrium.

A 23.45 Th 16:30 Lichthof

Probing an Ultracold Rb Cloud Stored in a Dipole Trap with Few and Single Atoms — •Oskar Fetsch, Wolfgang Alt, Shincy John, Amir Moqanaki, Nicolas Spethmann, Claudia Weber, Artur Widera, and Dieter Meschede — Institut für Angewandte Physik, 53115 Bonn, Deutschland

In this experiment, we aim on combining the advantages of single atom experiments with experiments dealing with ultracold quantum gases. Single and few Cs atoms are captured in a high-gradient magneto-optical trap (MOT) and the loading dynamics are observed through fluorescence detection. A Rb ensemble is cooled in a magnetic trap and then transferred using magnetic transport to a crossed dipole trap at the position of the Cs MOT. In this purely optical trap the Rb can be further cooled to quantum degeneracy. By transferring the Rb to a magnetic field insensitive state, it is possible to switch on the single atom MOT without affecting the Rb cloud. First experiments use few and single atoms trapped in a MOT to probe the ultracold Rb cloud. For further experiments, the internal spin degree of freedom of the Cs atoms needs to be manipulated. To accomplish this a species-selective optical lattice to trap the Cs atoms is set up.

A 23.46 Th 16:30 Lichthof

Towards a three-component Fermi gas in a 2D optical lattice — •Martin Ries[1,2], Philipp Simon[1,2], Thomas Lompe[1,2], Friedhelm Serwane[1,2], Gerhard Zürn[1,2], Timo Ottenstein[1,2], and Selim Jochim[1,2] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Physikalisches Institut, Universität Heidelberg

In our recent experiments, we have been studying a three-component Fermi gas with large scattering lengths. This system can serve as a simplistic model for QCD physics. Unfortunately, the stability of the three-component gas is limited in free space. However, there have been proposals on how to overcome this problem. For instance, the application of an optical lattice can improve the stability of the system drastically [1]. On the poster we present our progress setting up a new apparatus for these kind of experiments. We will use fermionic lithium in a 2D optical lattice. To achieve the necessary trapping and cooling of the atoms, we plan to use established components like a Zeeman slower, a magneto-optical trap as well as an optical dipole trap to cool the atoms to degeneracy. Additionally, there will be more advanced techniques for integrating and loading the optical lattice. A sophisticated imaging system will be needed to observe the atoms in our system.

[1] A. Kantian et al., arXiv.org:0908.3235 (2009)

A 23.47 Th 16:30 Lichthof

Simulation und Herstellung verschiedener zweidimensionaler Ionenfallen für die Quanteninformationsverarbeitung — •Michael Hellwig[1], Amado Bautista-Salvador[1], Frank Ziesel[1], Max Hettrich[1], Michaela Petrich[1], Kilian Singer[1], Günter Werth[2] und Ferdinand Schmidt-Kaler[1] — [1]Universität Ulm, Ulm, Deutschland — [2]Universität Mainz, Mainz, Deutschland

Wir beschreiben Fabrikationsmethoden und Design planarer Penning- und Paul-Fallen für Quanteninformationsverarbeitung. Sehr komplexe 2-dimensionale Fallenstrukturen lassen sich hochpräzise fertigen. Als Beispiel zeigen wir eine vielseitig verwendbare Penning Falle, bei der die Elektrodenkonfiguration in 2 Dimensionen sehr weitgehend modifiziert werden kann [1]. Obwohl das Einschlusspotential nur einige 100 meV beträgt sind Konfigurationen möglich, bei denen Ionen nahe an Oberflächen oder in frei konfigurierbaren 2-dimensionalen Kristallen gespeichert werden. In einer speziellen Paul-Falle können Ionen in starken magnetischen Gradientenfeldern gespeichert werden. Das ermöglicht die Kopplung zwischen Bewegungs- und Spin-Zuständen [2, 3]. Wir beschreiben die numerische Simulation der Fallenpotentiale, den Fertigungsprozess im Reinraum sowie erste experimentelle Resultate.

[1] - arXiv:0912.1533
[2] - Phys. Rev. Lett. 102, 073004 (2009)
[3] - Phys. Rev. A 79, 052324 (2009)

A 23.48 Th 16:30 Lichthof

Towards ultracold mixtures on an atom chip — •Sonali Warriar, Sebastian Nickel, Lucia Hackermüller, and Peter Krüger — University of Nottingham, Nottingham, United Kingdom

Ultracold mixtures hold the promise of understanding new phases of matter and collisions at very low energies. We are planning to set up experiments with Lithium and Cesium mixtures on a chip, i.e. ^{6}Li - ^{7}Li mixtures, heteronuclear LiCs or homonuclear ^{6}Li$_2$ molecules. By combining the capabilities of the atom chip with optical dipole trapping, it would be possible to trap these mixtures in low dimensions and tune their scattering lengths via Feshbach resonances. With atom chips, it would also be possible to realise experiments with additional magnetic potentials or have cold atoms interacting with a 2D electron gas. Here we present the current status of our experiment. This includes the setup of our lithium laser system, i.e. absorption spectroscopy and tapered amplifier laser setup. An illustration of our planned experimental chamber is also given.

A 23.49 Th 16:30 Lichthof

Ring-traps on atom chips — •Anton Piccardo-Selg, James Clewett, Sonali Warriar, Gal Aviv, Lucia Hackermüller, Thomas Fernholz, and Peter Krüger — University of Nottingham, United Kingdom

Atom chips allow for almost arbitrary trapping geometries for atomic ensembles by means of magnetic, electric, optical, microwave and radio-frequency potentials. We report on the setup of a new atom chip apparatus to create ring- and torus-shaped traps. These traps will be used to investigate the transition of a Bose-Einstein condensate when the dimensionality of the trapping geometry changes from 3D to 2D, and from 2D to 1D. Of particular interest are studies of low dimensional systems (2D and 1D) with periodic boundary conditions. Further we intend to use this configuration to create a Sagnac-like interferometer with ultracold atoms. The current progress of the experimental setup will be presented.

A 23.50 Th 16:30 Lichthof

An electric field generator for versatile trapping potentials in segmented microstructured ion traps — •M. T. Baig, M. Ziolkowski, M. Johanning, D. Kaufmann, and Chr. Wunderlich — Fachbereich Physik, Universität Siegen, 57072 Siegen, Deutschland

A collection of laser cooled ions stored in a micro structured Paul trap (microtrap) is a promising tool for investigations in quantum information science. Such microtraps allow for sculpting the electric potential experienced by individual ions and thus to shuttle ions between different trap locations. In addition, the range and strength of magnetic gradient induced coupling (MAGIC [1]) between spins can be varied by changing these potentials.

For controlling the quasi-dc voltages applied to individual electrodes of the microtrap, we set up a prototype electric field generator, initially to create 20 dc electric potentials which can be multiplexed and applied to 70 dc electrodes of the microtrap. Each channel contains its own memory, a digital-to-analog-converter and an amplifier so every channel can be programmed independently to get the desired potential at the output. This system has a 20 MHz update rate, is precise to 1 mV with peak to peak voltages up to 15 V and low in noise ($<\pm 0.5$ mV).

[1] M. Johanning, et al.; Phys. Rev. Lett. 102, 073004 (2009)

A 23.51 Th 16:30 Lichthof

Ultralong-range Rydberg Molecules: Investigation of a Novel Binding — •Björn Butscher[1], Vera Bendkowsky[1], Johannes Nipper[1], Jonathan Balewski[1], James P. Shaffer[1,2], Robert Löw[1], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Germany — [2]Homer L. Dodge Depertement of Physics ans Astronomy, University of Oklahoma, USA

For highly excited Rydberg atoms, the scattering of the Rydberg electron from a nearby polarizable ground state atom can generate an attractive mean-field potential which is able to bind the ground state atom to the Rydberg atom within the Rydberg electron wave function at binding energies ranging from a few MHz to hundreds of MHz[1].

We present spectroscopic data on the observation of various bound states including the vibrational ground and excited states of rubidium dimers Rb(5S)-Rb(nS) as well as those of trimer states. Furthermore, we show calculations that reproduce the observed binding energies remarkably well and reveal that some of the excited states are purely bound by quantum reflexion at a shape resonance for p-wave scattering.

To further charcterize the molecular states, we determine lifetimes and stark spectra of these molecules, which allow us to gain insight into the rotational structure of these molecules.

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

A 23.52 Th 16:30 Lichthof

Rydberg atom formation in strongly correlated ultracold neutral plasmas — •Georg Bannasch and Thomas Pohl — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden

In plasmas at very low temperatures the recombination into neutral atoms is dominated by three-body recombination, owing to the strong $\sim T^{-9/2}$ scaling of the recombination rate with the electron temperature. While this law is well established at high temperatures, the unphysical divergence as $T \to 0$ clearly suggests a breakdown in the low-temperature regime. Despite active debates about its extension into the low-temperature domain, and consequently strong coupling regime, a conclusive answer is still missing.

Here, we use a combined molecular dynamics - Monte Carlo method to investigate electron-ion recombination over a wide range of temperatures and densities. Through a careful analysis, we devise an approach that permits to distinguish recombined atoms from the surrounding plasma, i.e. to develop a chemical picture − even in the strongly coupled regime. Our method reproduces the known behavior of the recombination for high temperatures, but reveals significant changes as T decreases. We discuss the fate of the kinetic bottleneck and resolve the divergence-problem in the ultracold domain.

A 23.53 Th 16:30 Lichthof

Collective modes of ultracold neutral plasmas — •Andrei Lyubonko, Thomas Pohl, and Jan-Michael Rost — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

We study collective modes in an ultracold neutral plasma (UNP), as observed in recent experiments via microwave excitation of plasma electrons. The absence sharp boundary in freely expanding UNPs requires different approaches than used to understand the response of confined hot plasmas, but suggests an analogy to the behavior of hot stars.

We present extensive molecular dynamics simulations that reproduce experimental observations, upon a proper inclusion of temperature and charge imbalance effects. In contrast to previous believe, the calculations show that the found high-order resonances are not of Tonks-Dattner type. We elucidate the nature of these unusual modes, based on a hydrodynamical theory. Upon proper understanding such modes can serve as diagnostic tool to monitor the plasma temperature and other properties, such as the degree of neutrality during the expansion of ultracold plasmas.

A 23.54 Th 16:30 Lichthof

Image-potential states: A hydrogen-like system at metal surfaces — •Jens Güdde and Ulrich Höfer — Fachbereich Physik und Zentrum für Materialwissenschaften, Philipps-Universität, 35032 Marburg, Germany

Image-potential states represents a simple model system for the study of the complicated many-body interaction at solid surfaces. Electrons in these normally unoccupied states are bound perpendicular to the surface due to the potential well consisting of the coulomblike attractive image potential and the repulsive surface barrier. The resulting quantized electronic states form a hydrogenlike Rydberg series converging to the vacuum energy.

We present an overview of recent experiments in which the combination of coherent optical excitation with time- and angle-resolved two-photon photoemission (2PPE) has been used to study the coherent and incoherent dynamics of electrons in image-potential states on metal surfaces with femtosecond time resolution. This includes quantum-beat spectroscopy of image-potential states and resonances, their decoupling by rare-gas layers, and the generation and detection of coherently controlled ultrashort electrical current pulses at surfaces.

A 23.55 Th 16:30 Lichthof

The vibrational structure of ultralong-range Rydberg molecules — •Weibin Li, Jovica Stanojevich, Cenap Ates, Thomas Pohl, and Jan-Michael Rost — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Ultralong range Rydberg molecules have been observed by photoassociation spectroscopy recently in cold Rb atomic gases. These weakly bound molecules are formed by low energy scattering of Rydberg electron with ground state atoms, with binding length up to several thousand Bohr for high Rydberg states. A Green's function calculation gives consistent potential curves and is shown to explain most of the observed dimer lines. We reveal a new binding mechanism based on quantum reflection at a shape resonance for electron-atom scattering. Using a simplified model potential we elucidate the role of quantum reflection and the influence of the long-range potential shape onto the properties of the vibrational spectrum.

A 23.56 Th 16:30 Lichthof

Controlled Charge Transport in lattice confined Alkaline-Earth Gases — •Rick Mukherjee[1], Igor Lesanovsky[2], Alexander Eisfeld[1], and Thomas Pohl[1] — [1]Max-Planck-Institute for the Physics of Complex systems, Noethnitzer Str. 38, D-01187 Dresden, Germany — [2]School of Physics and Astronomy, The University of Nottingham, University Park, Nottingham NG7 2RD, UK

We study the dynamics of an ion immersed in an optical lattice of ultracold atoms. Optical dressing to Rydberg states is shown to permit precise and detailed control of charge exchange between neighboring lattice sites, thereby offering unique opportunities to steer coherent charge transport and implement, e.g. a range Holstein-Hubbard type Hamiltonians in optical lattices.

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. Our results show that the proposed scheme can be realized in ultracold Strontium lattices, as currently studied in several laboratories.

A 23.57 Th 16:30 Lichthof

Ultracold Rydberg trimers — •Iris Reichenbach, Weibin Li, Jovica Stanojevic, Thomas Pohl, and Jan-Michael Rost — Max Planck Institut für Physik komplexer Systeme, Dresden, Germany

The interactions of cold Rydberg atoms are an interesting system for both basic research as well as interesting novel applications like quantum information processing and ultracold chemistry. Recently, the formation of very large and loosely bound molecules consisting of one Rydberg atom and one other atom was predicted theoretically and realized experimentally. Here, we investigate the formation of similar Rydberg molecules, where the non-Rydberg atom is substituted by a molecular dimer, leading to an even richer but still tractable system, in which the energy of the Rydberg molecule depends on the orientation of the original dimer.

A 24: Atomic Clusters IV

Time: Friday 10:30–12:15 Location: F 303

Invited Talk A 24.1 Fr 10:30 F 303

Interacting Bosonic and Fermionic Atoms in 3D Optical Lattice Potentials — •Sebastian Will, Thorsten Best, Simon Braun, Philipp Ronzheimer, Ulrich Schneider, Michael Schreiber, Kin Chung Fong, Lucia Hackermüller, and Immanuel Bloch — Ludwig-Maximilians-Universität München, Schellingstraße 4, 80799 München, Germany

In recent years, ultracold atoms in optical lattices have begun to reveal their potential to simulate condensed matter systems with the exceptional control offered by atomic physics. We perform experiments directed towards quantum simulation using ultracold bosonic ^{87}Rb and fermionic ^{40}K atoms loaded to a 3D optical lattice, that features tunability of the underlying harmonic confinement. Additionally harnessing intra- and interspecies Feshbach resonances as a direct control knob for interactions, we investigate strongly interacting quantum systems along several routes: Using repulsively interacting ^{40}K Fermi-Fermi mixtures we have been able to realize an implementation of the Fermi Hubbard model. A direct measurement of compressibility allowed us to identify metallic, Fermi liquid and band insulating phases as well as an emergent Mott insulating phase. In ^{87}Rb-^{40}K Bose-Fermi mixtures we have characterized the shift of the bosonic superfluid to Mott insulating transition finding interaction-induced self-trapping to be the dominant cause. Recently, we have been able to peek beyond the single-band Hubbard model in a purely bosonic ^{87}Rb system: A precision measurement of the absolute interaction energies on the sites of a deep optical lattice revealed the presence of coherent multi-body interactions.

Invited Talk A 24.2 Fr 11:00 F 303

Dressing of Ground State Atoms by Rydberg States in a Ioffe-Pritchard Trap — •Michael Mayle[1], Igor Lesanovsky[2], and Peter Schmelcher[1] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg — [2]School of Physics and Astronomy, University of Nottingham, UK

Atomic Rydberg states possess extraordinary properties. Exploiting these qualities is demonstrated to create new handles for the manipulation of ultracold atoms. Taking the external motion of magnetically trapped (Rydberg) atoms as an example, we discuss how the specific features of the Rydberg state can be mapped onto the ground state by means of an off-resonant two-photon laser dressing. In particular, it is demonstrated that the interplay between the spatially varying quantization axis of the considered Ioffe-Pritchard field and the fixed polarization of the laser transition provides a possibility of substantially manipulating the ground state trapping potential.

A 24.3 Fr 11:30 F 303

Optical spectroscopy of metal doped silicon clusters in rare gas matrices — •Vicente Zamudio-Bayer[1], Konstantin Hirsch[1], Thomas Möller[1], Alexandre Rydlo[2], Stefan Minniberger[2], Wolfgang Harbich[2], Bernd von Issendorff[3], and Tobias Lau[4] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, EW 3-1, Hardenbergstraße 36, D-10623 Berlin — [2]Institut de Physique des Nanostructures, EPFL, CH-1015 Lausanne — [3]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg — [4]Helmholtz-Zentrum

Berlin für Materialien und Energie, Wilhelm-Conrad-Röntgen Campus / BESSY II, Institut für Methoden und Instrumentierung der Synchrotronstrahlung (G-I2), Albert-Einstein-Str. 15, D-12489 Berlin

Although theoretical studies predict technologically relevant optical properties for certain species of metal doped silicon clusters, such as large HOMO-LUMO gaps, these have not been studied experimentally. The reason for this is the very small achievable target density. In order to overcome this obstacle, we have taken our intense cluster source and combined it with a rare-gas matrix isolation apparatus at EPFL. With this setup it was possible to study the fluorescence and measure the excitation spectra of such clusters. This talk will cover the experimental setup and some preliminary results.

A 24.4 Fr 11:45 F 303

Ionization dynamics of NaCl-nanocrystals in strong laser fields — •Christian Peltz[1], Thomas Fennel[1], Egill Antonsson[2], Burkhard Langer[2], Jürgen Plenge[2], and Eckart Rühl[2] — [1]Institut für Physik, Universität Rostock, Universitätsplatz 3, 18051 Rostock — [2]Institut für Chemie und Biochemie, Freie Universität Berlin, Takustr. 3, 14195 Berlin

Insight into the ultrafast ionization dynamics of dielectrics in intense laser fields is of major interest for laser-based nanomachining and dielectric damage. The time-scale and nature of the mechanisms governing material modification and energy deposition, such as avalanche breakdown effects and plasma heating, are of central importance for realizing well-controlled material damage [1]. As finite and scalable gas phase model systems for solid dielectrics, NaCl-nanocrystals are promising systems to explore the time- and size-dependence of the coupling process. Experiments on these systems show pronounced pump-probe effects in the ion and electron emission with moderate laser intensities ($\sim 10^{13}\mathrm{W/cm^2}$). To investigate the microscopic ionization dynamics in such multi-component system we apply molecular dynamics simulation originally developed for intense laser-cluster interactions [2]. The simulation results, which are in good agreement with the experimental findings, reveal that avalanche-like metallization of the nanocrystals and resonant collective electron heating are the key to explain the observed timing effects on the ionization dynamics.

[1] L. Englert et al., Appl. Phys. A **92**, 749 (2008)
[2] T. Fennel et al., Phys. Rev. Lett. **99**, 233401 (2007)

A 24.5 Fr 12:00 F 303

Charge state selective double color landscapes of highly charged ions from clusters exposed to intense laser pulses — •Truong Nguyen Xuan, Josef Tiggesbäumker, and Karl-Heinz Meiwes-Broer — Institut für Physik, Universität Rostock, 18055 Rostock

We use the pulse shaping technique to investigate the interaction of intense femtosecond laser fields with embedded clusters. Colored doublepulses are used to systematiclly study the dependence of the extreme charging on the pulse energy, the pulse separation as well as the pulse intensity ratio. The prepulse intensity thresholds which have been extracted been extracted from the data show as remarkably low values which are nearly constant irrespective of the chosen charge state.

A 25: Precision Spectroscopy of Atoms and Ions III

Time: Friday 10:30–12:45 Location: F 107

A 25.1 Fr 10:30 F 107

Characterisation of a laser source for spectroscopy of trapped highly charged bismuth ions — •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

Our objective is to investigate the ground state hyperfine splitting of highly charged ions. Unprecedented precision and accuracy will be achieved by applying high resolution laser spectroscopy to ions cooled and stored in a Penning trap. This experiment is carried out within the SPECTRAP collaboration at GSI within the HITRAP facility.

For $^{209}\mathrm{Bi}^{82+}$ ions, transitions between hyperfine ground states can be exited using light at 243.9 nm. This light is produiced in a lasersystem and two frequency-doubling stages resulting in 15 mW in the UV. A Tellurium-cell was used as reference to measure the scan-range and reproduicibility in the range of 487.8 nm. In this presentation we describe schemes for laser stabilization and spectroscopic tests of the lasersystem performance.

A 25.2 Fr 10:45 F 107

Fluoreszenznachweis für die kollineare Laserspektroskopie am TRIGA-Mainz — •Michael Hammen[1], Klaus Eberhardt[1], Christopher Geppert[1,2], Jörg Krämer[1], Andreas Krieger[1], Rodolfo Sánchez[1,2], Bastian Sieber[1], Wilfried Nörtershäuser[1,2] und die TRIGA-SPEC-Kollaboration[1,2,3] — [1]Johannes Gutenberg-Universität Mainz, D-55099 Mainz — [2]GSI Helmholtzzentrum für Schwerionenforschung, D-64291 Darmstadt — [3]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117

TRIGA-LASER ist ein Aufbau zur kollinearen Laserspektroskopie an radioaktiven Isotopen am Forschungsreaktor TRIGA-Mainz und gleichezitig ein Prototyp für LASPEC an FAIR. Hierfür wurde ein optischer Fluoreszenznachweis entwickelt, der eine hohe Nachweiseffizienz mit einer guten Streulichtunterdrückung vereint. Zur Vorhersage des Verhaltens wurden Computersimulationen eingesetzt. Durch die Kombination von Metallspiegeln mit einem Blendensystem und speziellen Geometrien aus dem Bereich der nichtabbildenden Optiken gelingt es, eine maximale Konzentration des Lichts zu erreichen - was mit abbildenden Optiken nur schwer zu realisieren ist - und trotzdem das Streulicht selektiv zu absorbieren. Durch den Verzicht auf Lichtleiter und Linsen ist das System überdies für einen großen Wellenlängenbereich verwendbar.

A 25.3 Fr 11:00 F 107

Ein selbstangeregter Oszillator zur Messung der axialen Frequenz eines 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

In einem inhomogenen Magnetfeld ist die axiale Frequenz des Protons von dessen Spin-Zustand abhängig. Die Frequenzverschiebung, die durch eine Änderung der Spinausrichtung hervorgerufen wird, beträgt 200mHz bei einer axialen Frequenz von 700kHz. Ziel ist es, diesen Frequenzunterschied mit Hilfe eines Self-Excited-Oscillators aufzulösen [1]. Bei dieser Methode wird das vom Proton in den Fallenelektroden induzierte Signal auf das Teilchen zurückgekoppelt. Dies erlaubt die Bestimmung der axialen Frequenz bei viel höheren Bewegungsamplituden und damit einhergehend einer drastisch verkürzten Messzeit. Die Schwierigkeit besteht darin, die Bewegungsamplitude des Protons möglichst konstant zu halten, um Frequenzverschiebungen im nicht ganz homogenen Speicherfeld zu vermeiden. Hierzu wurde eine schnelle Regelungstechnik unter Verwendung eines digitalen Signalprozessors aufgebaut. Im Vortrag werden technische Aspekte zur Realisierung und erste Messungen präsentiert.

[1] D'Urso et al., Phys. Rev. Lett. **94**, 113002 (2005).

A 25.4 Fr 11:15 F 107

Application of electronic feedback to aproton stored in a cryogenic Penning trap — •Stefan Ulmer[1,2,3], Klaus Blaum[2,3], Holger Kracke[1], Andreas Mooser[1], Wolfgang Quint[4], Cricia Rodegheri[1], and Jochen Walz[1] — [1]Institut fürPhysik, Johannes Gutenberg-Universität Mainz, 55099 Mainz — [2]Max-Planck-Institut für Kernphysik, 69117Heidelberg — [3]Ruprecht-Karls-Universität, 69047Heidelberg — [4]GSI Darmstadt, 64291 Darmstadt

This experiment aims at the high precision measurement of the g-factor of the proton stored in a cryogenic Penning trap. The comparison of this number to the g-factor of the antiproton will give a stringent test of the CPT symmetry in the baryonic sector. Both quantities will be determined by the measurement of the particles eigenfrequencies in the Penning trap.

The axial frequency is measured with a highly sensitive superconducting detector, including an electronic feedback loop. The measured signal is fed back to the detector. Different aspects of this technique are discussed. Using positive feedback the signal to noise ratio increases. Thus, the axial frequency could be measured within 20 seconds to a relative precision of 10^{-7}. Furthermore with the high signal to noise ratio a novel detection schematic could be applied, which allows for the simultaneous measurement of the three eigenfrequencies of the trapped particle. Using negative feedback in combination with phase sensitive detection of the particle a frequency difference of 200 mHz was resolved in a 2 s measuring cycle. This resolution is sufficient to observe the effect of proton spin quantum jumps in the axial frequency.

A 25.5 Fr 11:30 F 107

Exciting and ionizing trapped highly charged ions with electrons and photons in an EBIT — •José R. Crespo López-Urrutia — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Hot cosmic matter, found in, e. g., around black hole accretion disks, in active galactic nuclei, supernova remnants, and in the warm-hot intergalactic medium can be prepared and studied in the laboratory with electron beam ion traps (EBITs). A fundamental interest arises from the fact that, for bound electrons, quantum electrodynamic (QED) as well as relativistic contributions grow steeply with the fourth power of the nuclear charge, and thus from small perturbations to major effects. Denuding atoms from most of their electrons in a controlled way exposes these magnified effects even better, and allows electronic correlation studies along isoelectronic sequences. In EBITs, highly charged ions (HCI) are produced, and their interactions with nearly monoenergetic electrons, with tunable lasers (both in the visible and soft X-ray region), and with keV photon beams from synchrotrons are used to excite and precisely measure electronic resonances. In particular, novel X-ray free-electron lasers (FLASH, LCLS), and synchrotron radiation (BESSY II) allow to go beyond the current accuracy limits. A report on recent results on few-electron QED, photoionization of HCI, dielectronic and trielectronic recombination processes, and laser spectroscopy of forbidden transitions investigated at the Heidelberg EBIT laboratory will be given.

A 25.6 Fr 11:45 F 107

Isotope shifts and hyperfine structure of the Fe I 372 nm resonance line — •Steffen Oppel[1], Stefanie Krins[2], Nicolas Huet[2], Joachim von Zanthier[1], and Thierry Bastin[2] — [1]Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg, Germany — [2]Institut de Physique Nucléaire, Atomique et de Spectroscopie, Université de Liège, Belgium

We report measurements of the isotope shifts of the $3d^64s^2\ a\ ^5D_4$ - $3d^64s4p\ z\ ^5F^o_5$ Fe I resonance line at 372 nm between all four stable isotopes ^{54}Fe, ^{56}Fe, ^{57}Fe, and ^{58}Fe, as well as the complete hyperfine structure of that line for ^{57}Fe, the only stable isotope having a non-zero nuclear spin. The field and specific mass shift coefficients of the transition have been derived from the data, as well as the experimental value for the hyperfine structure magnetic dipole coupling constant A of the excited state of the transition in $^{57}\mathrm{Fe}$: $\mathrm{A}(3d^64s4p\ z\ ^5F^o_5) = 81.69(86)$ MHz. The measurements were carried out by means of high-resolution Doppler-free laser saturated absorption spectroscopy in a Fe-Ar hollow cathode discharge cell using both natural and enriched iron samples. The measured isotope shifts and hyperfine constants are reported with uncertainties at the percent level [1].

[1] S. Krins, S. Oppel, N. Huet, J. von Zanthier, and T. Bastin, Phys. Rev. A **80**, 062508 (2009)

A 25.7 Fr 12:00 F 107

Nuclear proton distributions explored by relativistic resonance fluorescence — •Octavian Postavaru[1,2], Zoltán Harman[1,2], and Christoph H. Keitel[1] — [1]Max-Plank-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]ExtreMe Matter Institute EMMI, Planckstrasse 1, 64291 Darmstadt, Germany

Resonance fluorescence of laser-driven atoms is studied in the relativistic regime by solving the time-dependent Dirac equation in a multilevel model. Electron spin and retardation of the electron-photon interaction give rise to phenomena such as splitting of sideband peaks and modification of the Rabi frequencies not explainable in a Schrödinger theory. The approach based on the Dirac equation allows for investigating highly relativistic ions and, consequently, provides a sensitive means to determine parameters of nuclear charge distributions by applying coherent light with x-ray frequencies. Using two driving fields, one may obtain sub-natural linewidths in the emission spectra, increasing the sensitivity of nuclear proton distribution determinations.

A 25.8 Fr 12:15 F 107

A lifetime measurement of the $3p_{3/2}$ state in Mg^+ inferred from the spectral line shape of the D_2 transition — •Sebastian Knünz, Valentin Batteiger, Maximilian Herrmann, Theodor W. Hänsch, and Thomas Udem — MPQ, Garching, Germany

Recently we developed a spectroscopy scheme to obtain nearly perfect line profiles for atomic transitions in the weak binding limit using sympathetically cooled, single ion fluorescence readout. The symmetric, well understood line shape allowed us to extract the absolute frequency with an unprecedented accuracy [1,2]. The line shape is a convolution of a Gaussian due to the ion temperature and a Lorentzian which is the contribution due to the atomic upper state lifetime. A precision measurement of the Lorentzian contribution demands a more in-depth analysis of the experimental setup and the data evaluation methods. Here we report on numerical studies and estimation of the systematic uncertainty as well as our first measurements of the upper state lifetime of the D2 transition in Mg^+ using the atomic line shape. [1] M. Herrmann et al., Phys. Rev. Lett. 102, 013006 (2009). [2] V. Batteiger et al., Phys. Rev. A 80, 022503 (2009).

A 25.9 Fr 12:30 F 107

Fortschritte bei der Auffindung bislang unbekannter Energieniveaus des Pr-Atoms — Shamim Khan, Tanveer Iqbal, Imran Siddiqui, Bettina Gamper, Günter H. Guthöhrlein und •Laurentius Windholz — Inst. f. Experimentalphysik, Techn. Univ. Graz, Petersgasse 16, A-8010 Graz

Die Untersuchung der Hyperfeinstruktur nicht klassifizierbarer Pr-Spektrallinien erfolgt mittels Laseranregung und Beobachtung der laserinduzierten Fluoreszenz. Die große Anzahl der sich überlappenden Konfigurationen führt in der Regel zu Anregungs- und Fluoreszenzblends, daher ist eine Klassifizierung des angeregten Übergangs nur über die beobachtete Hyperfeinstruktur möglich. Aus dieser können die Drehimpulse und die Hyperfeinkonstanten A der am Übergang beteiligten Niveaus ermittelt werden. Meist kann das untere Niveau mit Hilfe des A-Faktors identifiziert werden. Die Addition der Anregungswellenzahl zur Wellenzahl des so ermittelten Niveaus liefert die Wellenzahl des unbekannten oberen Niveaus. Dessen Zerfall muß wiederum die beobachteten Fluoreszenzwellenlängen erklären. Die Existenz des neuen Niveaus wird durch weitere Laseranregungen bestätigt. Auf diese Weise konnten im letzen Jahr wieder mehr als hundert bislang unbekannte Energieniveaus aufgefunden werden.

A 26: Electron Scattering and Recombination / Interaction of Matter with Ions (with MO)

Time: Friday 10:30–12:45 Location: B 302

Invited Talk A 26.1 Fr 10:30 B 302

Electron-initiated Chemistry — Slim Chourou[1], Valery Ngassam[1], Asa Larson[2], and •Ann Orel[1] — [1]University of California, Davis, CA, USA — [2]Stockholm University, Stockholm, Sweden

Electron collisions with molecules and molecular ions that lead to dissociation play a key role in a number of environments, since they produce the radicals and molecular fragments that initiate and drive the relevant chemistries. These processes are dominated by resonances, that is, where the electron temporarily attaches to the molecule and change the forces felt between its atoms leading to a large coupling between the electron interaction with the target and the nuclear dynamics of the target. In our calculations, we carry out *ab initio* electron scattering calculations at fixed internuclear geometries to determine the resonant energy surfaces and the corresponding surface of autoionization widths, using the Complex Kohn variational method. These resonance positions and widths are then used as input to a dynamics study to determine the cross section and product distributions for the dissociation or excitation process. We will present results on a number of systems, including HCCH, HCN/HNC and HCCCN as examples of dissociative attachment, and CF^+ for dissociative recombination.

Invited Talk A 26.2 Fr 11:00 B 302

Astrophysically motivated electron collisions studies on M-shell iron ions — •Michael Lestinsky[1], Oldřich Novotný[1], Michael Hahn[1], Dietrich Bernhardt[2], Stefan Schippers[2], Alfred Müller[2], Claude Krantz[3], Manfred Grieser[3], Roland Repnow[3], Andreas Wolf[3], Nigel Badnell[4], and Daniel Wolf Savin[1] — [1]Columbia Astrophysics Laboratory, New York — [2]Institut für Atom- und Molekükphysik, Justus-Liebig-Universität, Gießen — [3]Max-Planck-Institut für Kernphysik, Heidelberg — [4]Department of Physics, University Strathclyde, Glasgow

Satellite X-ray observatories routinely observed spectroscopic features from M-shell iron ions in various cosmic sources. These observations are used to determine the properties of the observed objects. However, this requires accurate ionization balance calculations for the source which in turn necessitates reliable data for the electron-ion recombination process known as dielectronic recombination (DR) and also for electron impact ionization (EII). Utilizing the ion storage ring TSR, we are carrying out a series of energy-resolved DR and EII measurements in order to provide reliable for the astrophysics community. We compare our recent results for Fe^{11+} with modern theoretical calculations and with widely used models. Large differences are found in the low energy DR where an array of resonances enhances the measured DR by 10^2 as compared to theory. From our experimental data we derive plasma rate coefficients for both DR and EII for use in astrophysical models.

A 26.3 Fr 11:30 B 302

Finite basis set approach to the two–center Dirac problem — •Anton Artemyev and Andrey Surzhykov — Universität Heidelberg and GSI Helmholtzzentrum für Schwerionenforschung

Owing to the recent experimental advances in ion accelerator and storage ring techniques, more possibilities arise to study formation of quasi–molecules in (relatively) slow collisions of highly–charged, heavy ions. Extremely strong electromagnetic fields produced in these collisions are expected to cause a “decay” of unstable physical vacuum and a spontaneous creation of electron-positron pairs. Theoretical understanding of such an overcritical–field phenomenon requires, in general, solution of the two–center time–dependent Dirac equation. For low velocities of colliding ions this equation may still be treated adiabatically and, hence, can be traced back to the static (two–center) problem. In our work we developed an efficient method for dealing with this problem by utilizing finite basis sets constructed from B–splines. We argue that B–spline analysis can be performed most naturally in Cassini coordinates that are very efficient for the description of two–center Coulomb potential [1, 2]. To underline the advantages of the present approach, detailed calculations will be presented for quasi–molecular energy spectra obtained for slow symmetric (Z1 = Z2) as well as asymmetric (Z1 > Z2) ion–ion collisions.

[1] P. Schlüter, K.-H. Wietschorke, and W. Greiner, J. Phys. A v. 16, 1999, (1983).

[2] K.-H. Wietschorke, P. Schlüter, and W. Greiner, J. Phys. A v. 16, 2017, (1983).

A 26.4 Fr 11:45 B 302

Relativistic electron-ion recombination assisted by an intense laser field — •Carsten Müller, Alexander B. Voitkiv, and Bennaceur Najjari — Max-Planck-Institut für Kernphysik, Heidelberg

Radiative recombination of a relativistic electron with a highly charged ion in the presence of a strong laser field is considered. Various relativistic effects, arising from the high energy of the incoming electron and its strong coupling to the intense laser field, are found to clearly manifest themselves in the energy spectra of the emitted γ-photons. Moreover, characteristic shifts in the angular distributions are caused by the impact of the laser photon momentum.

[1] C. Müller, A.B. Voitkiv and B. Najjari, J. Phys. B 42, 221001 (2009)

A 26.5 Fr 12:00 B 302

Theory of higher-order resonant recombination processes in highly charged ions — •Zoltán Harman[1,2], Octavian Postavaru[1,2], Jacek Zatorski[1], and Christoph H. Keitel[1] — [1]Max-Plank-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]ExtreMe Matter Institute EMMI, Planckstrasse 1, 64291 Darmstadt, Germany

We report theoretical calculations on trielectronic recombination with simultaneous excitation of a K-shell and an L-shell electron, hence involving three active bodies. This process was identified in the x-ray emission spectrum of recombining highly charged Ar, Fe and Kr ions. For Kr^{30+}, inter-shell trielectronic recombination contributions of nearly 6% to the total resonant photorecombination rate were found [1]. We predict even higher contributions for lighter elements.

[1] C. Beilmann, O. Postavaru, L. H. Arntzen, *et al.*, Phys. Rev. A (R), **80**, 050702 (2009)

A 26.6 Fr 12:15 B 302

Measuring recoil ion momenta with high precision — •Simone Götz[1], Christoph S. Hofmann[1], Terry Mullins[2], Matthias Weidemüller[1], Alexey Sokolov[3], Wolfgang Quint[2], and Thomas Amthor[1] — [1]Universität Heidelberg, Philosophenweg 12, 69210 Heidelberg — [2]Universität Freiburg, Hermann-Herder Str. 3, 79104 Freiburg — [3]GSI Helholtzzentrum für Schwerionenforschung GmbH, Darmstadt

We present a transportable setup combining a dark SPOT (spontaneous optical trap) for Rubidium atoms with a recoil ion momentum spectrometer [1]. The very low thermal spread of the atoms in the trap, allows to measure the atom recoil momenta after interaction with photons or highly charged ions with very high precision. In collaboration with the GSI in Darmstadt we will investigate correlation effects in multiple charge transfer between the Rubidium atoms and highly charged ions.

In addition to the recoil ion momentum spectrometer with high resolution we discuss several other improvements of our setup, including enhanced optical access and a new mechanism for efficient loading of the magneto-optical trap with high flux.

[1] J. Ullrich *et al.*, J Phys. B **30**, 2971 (1997)

A 26.7 Fr 12:30 B 302

Collisions of low-energy antiprotons with He atoms — •Armin Lühr and Alejandro Saenz — Humboldt-Universität zu Berlin, Institut für Physik, Moderne Optik, Hausvogteiplatz 5-7, D-10117 Berlin

During the last two decades advances have been achieved in the understanding of antiproton ($\bar{p}$) collisions with the simplest one- and two-electron atoms H and He. However, in the case of $\bar{p}$ + He experiment and theory did not agree for impact velocities below the mean electron velocity for more than a decade stimulating a vivid theoretical activity.

Theoretical investigations for collisions of $\bar{p}$ with helium atoms in an energy range from 1 keV to 6 MeV have been performed. The He atom is described with a full two-electron approach which was recently applied in nonperturbative time-dependent calculations of $\bar{p}$ + H_2 collisions [1]. The scattering wave function is expanded in time-independent eigenstates of the target. The impact-parameter method is employed to describe the collision process. The present results for excitation and ionization are compared to experimental as well as theoretical data highlighting persisting inconsistencies among these data. The influence of two-electron effects as well as of expansion parameters on the outcome of the calculations is discussed.

[1] A. Lühr and A. Saenz, Phys. Rev. A **80**, (Rapid Communication) (2009)

A 27: Ultra-Cold Atoms, Ions and BEC IV / Interaction with VUV and X-Ray Light II (with Q)

Time: Friday 14:00–15:45 Location: F 303

A 27.1 Fr 14:00 F 303

Hunting for Efimov trimers in a three-component Fermi gas — •Thomas Lompe[1,2], Timo Ottenstein[1,2], Martin Ries[1,2], Friedhelm Serwane[1,2], Philipp Simon[1,2], Gerhard Zürn[1,2], and Selim Jochim[1,2] — [1]MPI für Kernphysik, Heidelberg — [2]Physikalisches Institut, Universität Heidelberg

In the past years Efimov states have been observed in a multitude of bosonic systems. In contrast, we study Efimov physics in a system of three distinguishable fermions with broad, overlapping Feshbach resonances. For each of these Feshbach resonances there exists a shallow dimer state, which creates a much richer system than a single resonance. So far we have found one loss resonance in three-atom- and two resonances in atom-dimer-scattering, which are caused by two Efimov trimers. This should allow for accurate predictions for the binding energies of these trimers. Additionally the fermionic nature of the atoms greatly enhances the stability of the Feshbach molecules, which makes the preparation of atom-dimer mixtures much easier than in bosonic gases. These properties make our system a promising candidate to attempt spectroscopy of Efimov states by RF-association of Efimov trimers.

A 27.2 Fr 14:15 F 303

Rydberg atoms in Bose-Einstein condensates and optical lattices — Matthieu Viteau[1], Jagoda Radogostowicz[1], Mark Bason[1], Nicola Malossi[1], Amodsen Chotia[2], Donatella Ciampini[1], •Oliver Morsch[2], and Ennio Arimondo[1,2] — [1]CNISM UdR Pisa, Dipartimento di Fisica, Largo Pontecorvo 3, 56127 Pisa, Italy — [2]CNR-INFM, Largo Pontecorvo 3, 56127 Pisa, Italy

We report on progress in exciting Rydberg states of Rubidium atoms in the Bose condensed phase and inside optical lattices. The high densities achievable in Bose-Einstein condensates give us access to a regime where dipole-dipole interactions between Rydberg atoms are strong, and the spatial order in optical lattices fixes a length scale for the interatomic distance. Both ingredients are essential for implementing controlled Rydberg-Rydberg interactions for quantum gates.

A 27.3 Fr 14:30 F 303

Optical Trapping of Magnesium — •Matthias Riedmann, Jan Friebe, Temmo Wübbena, André Kulosa, Hrishikesh Kelkar, Sana Amairi, André Pape, Sina Malobabic, Steffen Rühmann, Wolfgang Ertmer, and Ernst-Maria Rasel — Institut für Quantenoptik, Hannover, Germany

Magnesium is an interesting candidate for a future high performance neutral atom optical frequency standard. Long spectroscopy time and therefore high resolution can be reached by confining the atoms in the Lamb-Dicke regime in an optical lattice. Magnesium is challenging because cooling on the strong singlet transition is limited to the Doppler limit of 2 mK. Cooling on narrow lines, a standard technique to reach ultralow temperatures for other alkaline-earth atoms, is not promising for Mg because of a too narrow intercombination line (31 Hz).

Mg atoms are pre-cooled in a two-stage MOT. Atoms are first trapped on the strong singlet cooling transition and then pumped to the triplet system. There, another MOT operating between the ^3P and ^3D states is used to further cool and compress the atomic cloud. Atoms that decay to the $^3P_1$ state are repumped while those that decay to the $^3P_0$ are not and can be optically trapped by a 1064 nm dipole trap, which is superimposed with the second MOT. All cooling stages are running coutinously and atoms are accumulated in the dipole trap. The loss chnannel in the second MOT avoids a density limitation and therefore increases the loading to the dipole trap. With this technique, we are able to load up to $9 \cdot 10^4$ atoms to the dipole trap.

A 27.4 Fr 14:45 F 303

One-dimensional Anderson localization in correlated random potentials — •Pierre Lugan[1], Alain Aspect[1], Laurent Sanchez-Palencia[1], Dominique Delande[2], Benoit Grémaud[2,3], Cord A. Müller[2,4], and Christian Miniatura[3,5] — [1]Laboratoire Charles Fabry de l'Institut d'Optique, CNRS and Univ. Paris-Sud, Campus Polytechnique, RD 128, F-91127 Palaiseau Cedex, France — [2]Laboratoire Kastler-Brossel, UPMC, ENS, CNRS, 4 Place Jussieu, F-75005 Paris, France — [3]Centre for Quantum Technologies, National University of Singapore, 3 Science Drive 2, Singapore 117543, Singapore — [4]Physikalisches Institut, Universität Bayreuth, D-95440 Bayreuth, Germany — [5]Institut Non Linéaire de Nice, UNS, CNRS, 1361 Route des Lucioles, F-06560 Valbonne, France

The study of disorder with ultracold atomic gases has recently attracted much attention due to the possibility of controlling disorder, interactions, and dimensionality in these systems. In this contribution, we study the Anderson localization of ultracold atoms in weak, correlated one-dimensional potentials, and we discuss how the special long-range correlations present in the speckle potentials used in current experiments affect the localization properties of single particles and non-interacting wave packets. It is known that in one dimension generally all single-particle states are localized. For weak speckle potentials, we show the existence of a series of sharp cross-overs (effective mobility edges) between regions of the single-particle energy spectrum where the localization lengths differ by orders of magnitude [1].

[1] P. Lugan et al., Phys. Rev. A 80, 023605 (2009).

A 27.5 Fr 15:00 F 303

Aufbau zur Untersuchung freier nanoskopischer Partikel mit Synchrotronstrahlung — •Markus Eritt[1,2], Jan Meinen[1,2], Svetlana Khasminskaya[1,2], Egill Antonsson[3], Burkhard Langer[3], Eckart Rühl[3] und Thomas Leisner[1,2] — [1]Universität Heidelberg, Institut für Umweltphysik — [2]Karlsruher Institut für Technologie, Institute for Meteorology and Climate Research Atmospheric Aerosol Research (IMK-AAF) — [3]Freie Universität Berlin, Institut für Chemie und Biochemie

Es wir eine Apparatur zur Untersuchung freier, funktioneller Nanopartikel im Größenbereich von 3-300nm mit Synchrotronstrahlung vorgestellt. Die zu untersuchenden Partikel werden unter Atmosphärendruck erzeugt und durch ein Einlasssystem aus durchstimmbarer aerodynamischer Linse und RF-Ionenführung ins Vakuum transferiert. Um die zur Untersuchung freier Teilchen mit VUV-Strahlung nötigen hohen Targetdichten zu erreichen, werden die geladenen Nanopartikel in einer linearen Ionenfalle akkumuliert dort moderiert und dann und in dichten Pulsen in den VUV-Wechselwirkungsbereich eingeschossen. In einem ersten Experiment am BESSY II wurden die Photoelektronenspektren von 10nm Siliziumoxid Partikeln mit einem Elektronen-Flugzeitspektrometer aufgenommen. Vorgestellt werden die apparativen Möglichkeiten sowie erste Ergebnisse.

A 27.6 Fr 15:15 F 303

Collectivity and interference in x-ray scattering on nuclei — •Adriana Pálffy, Christoph H. Keitel, and Jörg Evers — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Resonant scattering of monochromatized synchrotron radiation or light from upcoming x-ray laser sources can lead to coherent photoexcitation of nuclei. Such an excitation in a nuclear ensemble is of excitonic nature, and the underlying collective effects determine the coherent nuclear reemission in the forward direction or at the Bragg angle. The coherent decay of the collective nuclear excitation is considerably speeded up with respect to the incoherent decay channels and thus to the natural lifetime. 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. 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 [2].

Based on the results of [1,2], we study here advanced coherent control schemes aimed at the selective population of nuclear states. We show that suppression of the coherent decay in resonant x-ray scattering can be used to control the effective branching ratio in nuclear systems, and thus the population of nuclear states. 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)

A 27.7 Fr 15:30 F 303

X-ray scattering and ionization of rare gas clusters by superintense pulses from the LCLS FEL — •Tais Gorkhover[1], Marcus Adolph[1], Daniela Rupp[1], Sebastian Schorb[1], Thomas

Möller[1], Sascha Epp[3], Robert Hartmann[4], Daniel Rolles[3], Artem Rudenko[3], Ilme Schlichting[3,5], Lothar Strüder[3,4], Joachim Ullrich[6], and Christoph Bostedt[2] — [1]TU Berlin — [2]LCLS, Stanford — [3]ASG — [4]MPI HLL — [5]MPI MF — [6]MPI K

The Linac Coherent Light Source (LCLS) is a new, world wide unique X-ray free electron laser (FEL), which produces ultrashort pulses up to 2keV with unprecedented brightness. One of the most promintent applications of this powerful tool is imaging of unrevealed ultrafast atomic and molecular processes. We report on the first imaging experiment at the LCLS. It was performed on rare gas clusters, which can be applied as simple model systems for interaction between X-ray laser and matter. We used single-photon counting pnCCD detectors for observing scattering and fluorescence. As clusters are destroyed by the ultra intense pulse, the observation of ionisation products is crutial for the understanding of interaction dynamics. They were detected simultaneously with advanced ion /electron spectrometers (VMI). This experiment was performed in the CFEL-ASG Multi-Purpose (CAMP) chamber which contains a unique combination of analysis instruments for exploring the interaction of intense (soft) x-ray radiation and matter.

A 28: Attosecond Physics II / Interaction with Strong or Short Laser Pulses III

Time: Friday 14:00–15:45 Location: F 107

A 28.1 Fr 14:00 F 107

Calibration of a High Harmonic Spectrometer by Laser Induced Plasma Emission — •Markus Gühr[1,2], Joseph P. Farrell[1,2], Brian K. McFarland[1,2], and Philip H. Bucksbaum[1,2] — [1]Stanford PULSE Institute, SLAC National Accelerator Laboratory, Menlo Park, USA — [2]Physics and Applied Physics, Stanford University, USA

We present a method that allows for a convenient switching between high harmonic generation (HHG) and accurate calibration of the vacuum ultraviolet (VUV) spectrometer used to analyze the harmonic spectrum. The accurate calibration of HHG spectra is becoming increasingly important for the determination of electronic structures. However, the wavelength of the laser harmonics themselves depend on the details of the harmonic geometry and phase matching, making them unsuitable for calibration purposes. In our calibration mode, the target resides directly at the focus of the laser, thereby enhancing plasma emission and suppressing harmonic generation. In HHG spectroscopy mode, the source medium resides in front or after the focus, showing enhanced HHG and no plasma emission lines. The plasma lines can be used for calibrating the spectrometer and we achieve an accuracy of 0.1 nm, which is more than an order of magnitude more accurate than a calibration using the harmonics [1].

[1] J. P. Farrell, B. K. McFarland, P. H. Bucksbaum and M. Gühr, Optics Express, 17, 15142 (2009)

A 28.2 Fr 14:15 F 107

Isolated attosecond laser pulses tunable between 80 and 100 eV — •Markus Fiess[1], Balint Horvath[2], Reinhard Kienberger[1], and Ferenc Krausz[1] — [1]Max-Planck-Institut für Quantenoptik, Garching, Deutschland — [2]ABB, Baden-Dättwil, Schweiz

We report on the generation of isolated attosecond laser pulses tunable in the spectral range between 80 and 100 eV which are generated by high harmonic generation in Ne-gas with driving laser pulses and its second harmonic. We present XUV spectra for different fundamental waveforms which are synthesized by controlling the phase delay between the driving laser field and its second harmonic wave.

A 28.3 Fr 14:30 F 107

Quasi-elastic electron scattering from atoms and molecules — Adam P. Hitchcock[1], Glyn Cooper[1], Russ A. Bonham[2], and •Aris C. C.-Dreismann[3] — [1]Brockhouse Institute for Materials Research, McMaster University, Hamilton, ON, L8S 4M1, Canada — [2]Department of Biological, Chemical and Physical Sciences, Illinois Institute of Technology, Chicago, Illinois 60616, USA — [3]Institute of Chemistry, Sekr. C2, Technical University of Berlin, D-10623 Berlin

We have measured quasi-elastic electron scattering spectra from molecules and atoms at large momentum transfer Q (100 deg. angle, 2.25 keV incident energy, Q~20 a.u.). The peak positions agree completely with those predicted by classical conservation of momentum and energy, assuming the electron scatters from each atom independently. However the peak intensities do not agree with expectations, particularly for light elements. According to classical electron Compton scattering, quasi-elastic peak intensities should be propotional to nuclear charge squared. However, our recent study [1] found a significant deviation (~30%) in the intensities of the H versus D signals relative to this prediction. Here we present new quasi-elastic electron scattering data for H2/D2, Ar/H2, Ar/D2, He/H2 and Ar/He mixtures [2]. Large deviations from conventional theoretical expectations are obserded, for all samples. The possible connection of this striking effect with decoherence and the quantum Zeno effect is shortly mentioned.

[1] G. Cooper et al., PRL 100, 043204 (2008). [2] A. P. Hitchcock et al., J. Electron Spectrosc. Relat. Phenom., in press (2010)

A 28.4 Fr 14:45 F 107

Attosecond Transient Absorption Spectroscopy — •Adrian Wirth[1], Eleftherios Goulielmakis[1], Zhi-Heng Loh[2], Robin Santra[3], Nina Rohringer[4], Vladislav S. Yakovlev[5], Sergey Zherebtsov[1], Thomas Pfeifer[2], Abdallah M. Azzeer[6], Matthias F. Kling[1], Stephen R. Leone[2], and Ferenc Krausz[1,5] — [1]Max-Planck-Institut für Quantenoptik, Garching, Germany — [2]Departments of Chemistry and Physics, University of California, Berkeley, USA — [3]Department of Physics, University of Chicago, Chicago, USA — [4]Lawrence Livermore National Laboratory, Livermore, USA — [5]Department für Physik, Ludwig-Maximilians-Universität, Garching, Germany — [6]Physics and Astronomy Department, King Saud University, Kingdom of Saudi Arabia

The electronvolt-scale energy spacing of quantum states in the valence shell of atoms and molecules implies electron motion which unfolds in the range of a few tens of attoseconds to a few femtoseconds. Efforts of accessing those ultrafast dynamics comprise the generation of isolated soft-x-ray attosecond pulses and the control of light fields. We show that a combination of attosecond technology and x-ray absorption spectroscopy is able to further expand the horizon of attosecond science. This opens the door for gaining direct, time-domain insight into quantum coherences and connected electron density motion in the valence shell of atoms and molecules. In a proof-of-principle experiment we traced for the first time valence electron motion in Kr ions in real time and could completely reconstruct the strong-field initiated spin-orbit wavepacket coherence and quantum level population.

A 28.5 Fr 15:00 F 107

Ion Microscopy with XUV-Radiation at FLASH — •Boris Bergues[1], Martin Schultze[1], Matthias Kling[1], Oliver Herrwerth[1], Adrian Wirth[1], Wolfram Helml[1], Matthias Lezius[1], Gilad Marcus[1], Michael Hofstetter[1], Peter Lang[1], Reinhard Kienberger[1], Karl-Ludwig Kompa[1], Ferenc Krausz[1], Artem Rudenko[2], Kai-Uwe Kühnel[3], Claus Dieter Schröter[3], Robert Moshammer[3], Joachim Ullrich[3], Rolf Treusch[4], Stefan Düsterer[4], and Hartmut Schröder[1] — [1]Max-Planck-Institut für Quantenoptik, Garching, Germany. — [2]Max-Planck Advanced Study Group at CFEL, Hamburg, Germany. — [3]Max-Planck-Institut für Kernphysik, Heidelberg, Germany. — [4]HASYLAB at DESY, Hamburg, Germany.

A novel technique is presented, that allows a spatially resolved photoionization-yield measurement of gas-phase ions created in the interaction volume of an intense-laser focus. The method termed 'ion microscopy' thus overcomes the limitations usually imposed by the integration of the ion yield over the focal volume. Moreover, the new technique represents a precise tool for non invasive, in situ focus diagnostics and is applied to characterize the focal geometry of focused XUV-radiation generated at the FLASH facility in Hamburg.

A 28.6 Fr 15:15 F 107

Studying dynamics of Xenon clusters in ultra high intense femtosecond Xray laser pulses via single shot single cluster imaging at LCLS and FLASH — •D. Rupp[1], M. Adolph[1], T. Gorkhover[1], S. Schorb[1], T. Möller[1], D.

Rolles[3], A. Rudenko[3], S. Epp[3], R. Hartmann[3,4], L. Strüder[3,4], I. Schlichting[3,5], J. Ullrich[3,6], and C. Bostedt[2] — [1]TU Berlin — [2]LCLS — [3]ASG — [4]MP HLL — [5]MPI MF — [6]MPI K

With the recent rapid development of Free Electron Lasers (FELs) in the high energy photon range, unique novel experiments as imaging of single nanoscale objects down to atomic resolution come into reach. Due to the severe energy deposition in the imaged particles ultrafast electron and ion dynamics are initiated and the understanding of these processes is crucial for the success of such experiments. In a first experiment at FLASH at 90eV photon energy it has been shown that imaging of single Xenon clusters with ultrashort FEL pulses is possible and a promising method to study these dynamics on a femtosecond time scale. We now present latest results from the very first imaging experiments at LCLS. Xenon clusters were irradiated by pulses with photon energies up to 2 keV at varied pulse lengths from 400 down to 4 femtoseconds. The experiment was performed in the CFEL-ASG Multi-Purpose (CAMP) End Station, which provides a combined imaging and spectroscopic approach with new developed large area pnCCDs for scattered and fluorescence light complemented by electron and ion VMI-spectrometers.

A 28.7 Fr 15:30 F 107

The mechanisms underlying strong field double ionization of argon dimers — •Bastian Manschwetus[1], Horst Rottke[1], Günther Steinmeyer[1], Lutz Foucar[2], Armin Czasch[3], Horst Schmidt-Böcking[3], Reinhard Dörner[3], and Wolfgang Sandner[1] — [1]Max-Born-Institut, Max-Born-Str. 2A, 12489 Berlin, Germany — [2]Max Planck Advanced Study Group, Center for FEL Science, 22761 Hamburg, Germany — [3]Inst. für Kernphysik, Goethe Univ. Frankfurt, Max-von-Laue-Str. 1, 60438 Frankfurt, Germany

We investigate double ionization of argon dimers in high intensity ultra-short Ti:Sapphire laser pulses. We find atomic ion pairs from Coulomb explosion of the doubly charged dimer which can be attributed to two-site single ionization, and to one-site single ionized and exited configurations of the dimer which Coulomb explode after electron exchange accompanied by emission of a second electron at short internuclear separation. A possible excitation mechanism for this second channel is tunnel ionization of one electron accompanied by shake-up of a second one. High energy ion pairs are attributed to Coulomb explosion of the double ionized dimer after additional excitation of an electron to a Rydberg state by frustated tunnel ionization [1] or by inelastic scattering excitation of the ion by the returning laser accelerated electron. The dissociation of this exited double ionized dimer ion is similar to Coulomb explosion of a triple ionized dimer until shielding of the charge of the Ar^{++} ion by the Rydberg electron becomes significant at large internuclear separation.

[1] Eichmann *et al.* Phys. Rev. Lett. **101**, 233001 (*2008*)

A 29: Atomic Systems in External Fields II

Time: Friday 14:00–16:00 Location: B 302

A 29.1 Fr 14:00 B 302

A database for bound-bound transitions using a Hartree-Fock-Roothaan method for atoms and ions in neutron star magnetic fields — •Christoph Schimeczek and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart, 70550 Stuttgart

In the immediate vicinity of neutron stars very strong magnetic fields in the range of 10^8 T exist. To acquire information about the composition of the atmosphere of such neutron stars, observed spectra have to be analyzed using numerically calculated atomic data. Applying a Hartree-Fock-Roothaan scheme, we have calculated a comprehensive data base for bound-bound transitions and spectra for atoms in different ionization states up to Fe.

A 29.2 Fr 14:15 B 302

Production of Antihydrogen via Double-Charge-Exchange — •Andreas Müllers[1], Robert McConnell[3], Jochen Walz[1], Eric Hessels[2], Cody Storry[2], Andrew Speck[4], and Gerald Gabrielse[3] — [1]Johannes Gutenberg Universität, Institut für Physik, 55099 Mainz — [2]York University, Canada — [3]Harvard University, USA — [4]Rowland Institute at Harvard, USA

Comparison of the 1s-2s transitions in hydrogen and antihydrogen will provide an accurate test of CPT symmetry. While production of antihydrogen using the three-body-recombination (TBR) scheme is an established technique at CERN's Antiproton Decellerator facility (AD), trapping these atoms for spectroscopy has not yet succeeded. Therefore, the ATRAP collaboration has developed a different scheme to produce much colder anti-atoms more suitable for trapping. Cesium atoms are laser-excited to Rydberg-states and travel through positrons stored in a Penning-trap. A collisional charge exchange reaction produces positronium, which is no longer confined by the Penning-trap fields. It can therefore interact with nearby stored antiprotons, creating antihydrogen. The principle was demonstrated in 2004. Since then, ATRAP has developed a new apparatus providing larger particle numbers and a quadrupole Ioffe-trap for neutral atoms. Furthermore, a new solid state laser-system for Cesium excitation has been developed. During the past AD-beam-run, the excitation of cesium to various high-n-states within the $1\,T$ bias field of the Penning trap has been demonstrated.

A 29.3 Fr 14:30 B 302

Sub-Poissonian atom number fluctuations by three-body loss in mesoscopic ensembles — •Shannon Whitlock, Caspar Ockeloen, and Robert Spreeuw — Van der Waals-Zeeman Institute, University of Amsterdam, The Netherlands

We show that three-body loss of trapped atoms leads to sub-Poissonian atom number fluctuations. We prepare hundreds of dense ultracold ensembles in an array of magnetic microtraps on a permanent-magnet atom chip. We observe rapid losses due to three-body recombination. The resulting shot-to-shot fluctuations of the number of atoms per trap are sub-Poissonian, for ensembles comprising 50–300 atoms. The measured relative variance or Fano factor $F = 0.53 \pm 0.22$ agrees very well with the prediction by an analytic theory ($F = 3/5$) and numerical calculations. Density dependent loss such as three-body recombination can thus be used to prepare small and well-defined numbers of atoms in each microtrap. These results will facilitate studies of quantum information science with mesoscopic ensembles.

A 29.4 Fr 14:45 B 302

Coupled electronic and nuclear fluxes in molecules — •Kenfack A.[1], Banerjee S.[1], Barth I.[1], Hege H. C.[2], Ikeda H.[3], Koppitz M.[2], Lasser C.[4], Manz J.[1], Marquardt F.[2], Paulus B.[1], and Paramonov G. K.[1] — [1]Inst. Chem. Bio., FU Berlin — [2]Zuse Inst. Berlin — [3]Dept. of Applied Chemistry, Osaka Prefecture University, Japan — [4]Fachbereich Mathematik, FU Berlin

We propose a new approach for evaluating nuclear and electronic fluxes in molecules. This is based on the Born-Oppenheimer approximation which, though excellent for densities and time dependent molecular properties, is not appropriate for electronic fluxes computed from the flux density equation. However making use of the Gauss's theorem and the continuity equation, we successfully solved this problem by formulating fluxes in terms of integrals of densities[1]. This new approach, applied to coherent vibrations of small molecules, agrees quite well with the accurate one[2]. With H2+ and D2+, we find that the electronic flux is no longer zero and, that the electron does not always adapt quasi-instantaneously to the nuclear motion. Moreover we show that the initial state preparation matters[3]. In particular, the nuclear flux exhibits high frequency oscillations when the process starts in the inner turning point in contrast to the outer one. Considering H2, the effect of electronic correlation has been investigated by comparison of the Hartree-Fock and the full configuration interaction methods.

[1] I. Barth et al. Chem. Phys. Lett.481, 118 (2009) [2] Chelkowsky et al. Phys. Rev. A 52, 2977 (1995), G. K. Paramonov, Chem. Phys. Lett. 411, 350 (2005) [3] Kenfack et al. (in preparation) (2008)

A 29.5 Fr 15:00 B 302

Charge Breeding with Dresden EBIS/T systems — •Alexandra Thorn[1], Alexey Sokolov[2], Gleb Vorobjev[2], Frank Herfurth[2], Oliver Kester[2], Erik Ritter[1], Falk Ullmann[3], and Günter Zschornack[1] — [1]Institut für Angewandte Physik, Technische Universität Dresden, Germany — [2]Gesellschaft für

Schwerionenforschung, Darmstadt, Germany — [3]Dreebit GmbH, Dresden, Germany

High-precision atomic mass measurements or nuclear fusion reaction studies are two examples for projects which rely on the availability of highly charged ions (HCI) from a broad spectrum of elements or exotic isotopes. However, the desired HCI often cannot be provided directly from one source. Thus, initially low charged ions have to be converted or "bred" to higher charge states. We have performed simulations as well as x-ray and ion extraction measurements to investigate the possibilities of charge breeding with the SPARC-EBIT, a compact room-temperature electron beam ion trap of the Dresden EBIT type. K^{1+} ions produced by a surface ion source were injected into the EBIT and bred to charge states as high as K^{19+}. Continuous as well as pulsed injection methods were tested revealing details about the process of filling the electrostatic trap of the EBIT with externally produced ions. Experimentally achieved capture and breeding efficiencies for various charge states are summarized and the application of advanced charge breeding techniques with the Dresden EBIT are discussed.

A 29.6 Fr 15:15 B 302

Spontaneous emission of light from atoms — •Nikodem Szpak[1] and Piotr Marecki[2] — [1]Fakultät für Physik, Universität Duisburg-Essen — [2]Institut für Theoretische Physik, Universität Leipzig

We investigate (non-relativistic) atomic systems interacting with quantum electromagnetic field (QEF). The resulting model describes spontaneous emission of (single) photons from a two-level atom. By conducting the analysis on a general level we allow for an arbitrary initial state of the QEF (which can be for instance: the vacuum, the ground state in a cavity, or the squeezed state). We derive a Volterra-type equation which governs the time evolution of the amplitude of the excited state. In the vacuum case we analytically determine the asymptotics of its solutions: exponential decay at intermediate times and power-law decay at very late times. We also solve this equation numerically.

A 29.7 Fr 15:30 B 302

k-Photon Decay Rates from Complex Dilated Floquet Hamiltonians — Celsus Bouri, Andreas Buchleitner, Pierre Lugan, Sören Roerden, Maximilian Schmidt, and •Klaus Zimmermann — Physikalisches Institut, Universität Freiburg

Complex dilation is known as an efficient tool for the extraction of total decay rates of atomic systems under strong external perturbations. This method is however believed to be unsuited to access partial decay rates into specific decay channels. We show that the latter indeed can be derived from the eigenstates of complex dilated Hamiltonians. As a specific example we demonstrate our novel approach to quantify the decay rates of periodically driven Rydberg systems into well defined k-photon ionisation channels.

A 29.8 Fr 15:45 B 302

Frozen planet states in helium with non-zero angular momentum — •Celsus Bouri[1,2], Johannes Eiglsperger[3], Javier Madronero[3,4], and Andreas Buchleitner[1] — [1]Quantum Optics and Statistics, Institute of Physics, University of Freiburg, 79104 Freiburg, Germany — [2]CEPAMOQ, University of Douala, B.P. 8580 Douala, Cameroon — [3]Physik Department, Technische Universität München, 85747 Garching, Germany — [4]Laboratoire de Physique Atomique, Moléculaire et Optique (PAMO), Université catholique de Louvain, 1348 Louvain-la-Neuve, Belgium

We demonstrate the existence of frozen planet states (FPS) in helium for total angular momenta $L = 1$ and $L = 2$. The calculations are conducted for the planar (2D) and for the full 3-dimensional (3D) helium. The simplified planar model reproduces the reproduces qualitavely well the results of our full 3D appraoch. The identification of the FPS is achieved through the localitation properties of their wavefunction in configuration space. The small magnitude of their decay rates and the large value of $\langle \cos\theta_{12} \rangle$, θ_{12} being the mutual angle between the two electrons, characterize $L = 1$ FPS. These two quantities can be used to identify these states. These simple criteria do not apply for D states. Here, the localization properties of the wave functions both in configuration and phase space need to be analyzed.