Fachverband Atomphysik (A)

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Übersicht der Hauptvorträge und Fachsitzungen

(Hörsäle 6G, 5M und 5D)

Hauptvorträge

A 2.1	Mo	10:30–11:00	6G	**High-precision atomic physics experiments with stored and cooled ions in Penning traps** — •Klaus Blaum
A 3.1	Mo	10:30–11:00	5M	**Inelastic interaction of free electrons with pristine and doped rare gas clusters** — •Paul Scheier, Stephan Denifl, Fabio Zappa, Philipp Sulzer, Ingo Mähr, Andreas Mauracher, Tilmann Märk
A 4.1	Mo	14:00–14:30	6G	**Effiziente Autoionisation schwach gebundener Cluster durch Interatomaren Coulomb-Zerfall (ICD)** — •Uwe Hergenhahn, Silko Barth, Volker Ulrich, Simon Marburger, Markus Lundwall, Gunnar Öhrwall, Olle Björneholm
A 6.1	Mo	16:30–17:00	5M	**Quantum mechanics without wavefunction - a density functional perspective on electron dynamics** — •Stephan Kümmel
A 7.1	Di	10:30–11:00	5M	**Rydberg atom and molecule optics** — •Frederic Merkt, Edward Vliegen, Stephen Hogan
A 8.1	Di	14:00–14:30	6G	**Antihydrogen studies with ATHENA** — •Alban Kellerbauer
A 9.1	Di	14:00–14:30	5M	**Correlated electron dynamics in few-cycle pulses** — •Andreas Becker
A 17.1	Mi	14:00–14:30	6G	**Multielectron wave-packet propagation for electron dynamics following ionization: Basics and explicit applications** — •Alexander Kuleff, Lorenz Cederbaum
A 18.1	Mi	16:30–17:00	6G	**Röntgen-Laserspektroskopie mit hochgeladenen Ionen am Freie-Elektronen-Laser FLASH** — •José Crespo López-Urrutia, Sascha Epp, Joachim Ullrich
A 19.1	Do	11:30–12:00	5M	**Photophysics of DNA: Relation between structure and dynamics in isolated clusters** — •Thomas Schultz, Elena Samoylova, Hans-Hermann Ritze, Wolfgang Radloff, Yuliya Rulyk, Ingolf Volker Hertel
A 20.1	Do	11:30–12:00	6G	**Controlling Ultracold Rydberg Atoms in the Quantum Regime** — •Igor Lesanovsky
A 27.1	Fr	10:30–11:00	6G	**Quantum effects in collisions of ultracold atoms with walls and nanostructures** — •Javier Madroñero, Florian Arnecke, Alexander Jurisch, Harald Friedrich
A 28.1	Fr	10:30–11:00	5M	**Angular analysis of x–ray emission from excited ionic states with unresolved fine structure** — •Andrey Surzhykov, Ulrich Jentschura, Thomas Stöhlker, Stephan Fritzsche

Fachsitzungen

A 1.1–1.9	Mo	10:30–12:45	6J	**Quantengase (jointly with Q)**
A 2.1–2.7	Mo	10:30–12:30	6G	**Precision spectroscopy I**
A 3.1–3.7	Mo	10:30–12:30	5M	**Atomic Clusters I**
A 4.1–4.7	Mo	14:00–16:00	6G	**Atomic Clusters II**
A 5.1–5.7	Mo	16:30–18:15	6G	**Precision spectroscopy II**
A 6.1–6.7	Mo	16:30–18:30	5M	**Interaction with strong laser pulses I**

A 7.1–7.5	Di	10:30–12:15	5M	**Ultracold Plasmas and Rydberg Dynamics (jointly with Q)**
A 8.1–8.7	Di	14:00–16:00	6G	**Precision Spectroscopy III**
A 9.1–9.7	Di	14:00–16:00	5M	**Interaction with strong laser pulses II**
A 10.1–10.10	Di	16:30–18:30	Poster B	**Poster I - Precisions Spectroscopy**
A 11.1–11.11	Di	16:30–18:30	Poster B	**Poster I - Collisions with electrons and ions**
A 12.1–12.5	Di	16:30–18:30	Poster B	**Poster I - Interaction with external fields**
A 13.1–13.4	Di	16:30–18:30	Poster B	**Poster I - Ultra-cold plasmas and Rydberg systems**
A 14.1–14.10	Di	16:30–18:30	Poster B	**Poster I - Ultra-cold atoms, ions and BEC**
A 15.1–15.6	Mi	11:30–13:00	5M	**Atomic Systems in External Fields I**
A 16.1–16.1	Mi	11:30–12:00	6J	**Robert-Wichard-Pohl Preisträgervortrag**
A 17.1–17.7	Mi	14:00–16:00	6G	**Attosecond Physics (jointly with Q)**
A 18.1–18.7	Mi	16:30–18:30	6G	**Interaction with VUV and X-Ray light**
A 19.1–19.5	Do	11:30–13:00	5M	**Photoionization**
A 20.1–20.6	Do	11:30–13:15	6G	**Atomic Systems in External Fields II**
A 21.1–21.8	Do	14:00–16:00	5D	**Innovative Traps and Cooling Schemes (jointly with Q)**
A 22.1–22.12	Do	16:30–18:30	Poster B	**Poster II - Atomic clusters**
A 23.1–23.16	Do	16:30–18:30	Poster B	**Poster II - Interaction with strong or short laser pulses**
A 24.1–24.5	Do	16:30–18:30	Poster B	**Poster II - Interaction with VUV and X-ray light**
A 25.1–25.4	Do	16:30–18:30	Poster B	**Poster II - Photoionization**
A 26.1–26.4	Do	16:30–18:30	Poster B	**Poster II -Attosecond physics**
A 27.1–27.7	Fr	10:30–12:30	6G	**Ultracold collisions (jointly with Q)**
A 28.1–28.6	Fr	10:30–12:15	5M	**Collisions with electrons and ions (jointly with MO)**

Mitgliederversammlung des Fachverbands Atomphysik

Mittwoch 13:00 6G

- Bericht
- Format und Orte zukünftiger Frühjahrstagungen
- Allgemeines

A 1: Quantengase (jointly with Q)

Zeit: Montag 10:30–12:45 Raum: 6J

A 1.1 Mo 10:30 6J

Interference of one-dimensional quasi-condensates — •Sebastian Hofferberth[1], Igor Lesanovsky[2], Stephanie Manz[1], Thorsten Schumm[1], and Jörg Schmiedmayer[1] — [1]Atominstitut der Österreichischen Universitäten, TU-Wien, Stadionallee 2, A-1020 Vienna, Austria — [2]Universität Innsbruck, Institute for Quantum Optics and Quantum Information, A-6020 Innsbruck, Austria

Phase fluctuations play an important role in one-dimensional systems, preventing true long range phase order even at zero temperature. We study the thermal phase fluctuations in a one-dimensional Bose gas by coherently splitting a single quasi-condensate and observing interference between the two resulting matter wave packets.

Our interferometer scheme is based on radio-frequency induced adiabatic potentials implemented on an atom chip, which allows us to prepare two quasi-condensates with a defined macroscopic relative phase [1] . The phase fluctuations lead to an intrinsic dephasing over time, which can be extracted from the observed interference patterns [2].

We study the dependence of the dephasing time on the density in the quasi-condensates and the trap parameters. Additionally we investigate how a finite tunnel-coupling between the two systems affects the dynamics of the relative phase.

[1] S. Hofferberth, I. Lesanovsky, B. Fischer, J. Verdu and J. Schmiedmayer, Nature Phys. 2, 710 (2006) [2] V. Gritsev, E. Altman, E. Demler and A. Polkovnikov, Nature Phys. 2, 705 (2006)

A 1.2 Mo 10:45 6J

Comparing Contact and Dipolar Interactions in a Bose-Einstein Condensate — •Axel Griesmaier, Jürgen Stuhler, Tobias Koch, Marco Fattori, Stefano Giovanazzi, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany

We have measured the relative strength ε_{dd} of the magnetic dipole-dipole interaction compared with the contact interaction [1] in a dipolar chromium Bose-Einstein condensate [2]. We analyze the asymptotic velocities of expansion of the condensate with different orientations of the atomic magnetic moments. By comparing the experimental results with numerical solutions of the hydrodynamic equations for dipolar condensates, we obtain $\varepsilon_{dd} = 0.159 \pm 0.034$. We use this result to determine the s-wave scattering length $a = (5.08 \pm 1.06)\ 10^{-9}m= (96 \pm 20)\ a_0$ of ^{52}Cr. This is fully consistent with our previous measurements on the basis of Feshbach resonances [3] and therefore confirms the validity of the theoretical approach used to describe the dipolar Bose-Einstein condensate.

[1] A. Griesmaier *et al.*, Phys. Rev. Lett. in press (2006).
[2] A. Griesmaier *et al.*, Phys. Rev. Lett. **9**4, 160401 (2005).
[3] J. Werner *et al.*, Phys. Rev. Lett. **9**4, 183201 (2005).

A 1.3 Mo 11:00 6J

Critical behavior of a trapped interacting Bose gas — •Tobias Donner, Stephan Ritter, Thomas Bourdel, Ferdinand Brennecke, Anton Öttl, Michael Köhl, and Tilman Esslinger — Institut für Quantenelektronik, ETH Zürich, 8093 Zürich, Schweiz

In the vicinity of a phase transition minute variations in the controlling parameters can dramatically change the properties of a system. Using a trapped Bose gas we have entered the critical regime of Bose-Einstein condensation and gained access to its beyond mean-field physics. This regime is characterized by fluctuations extending far beyond the thermal de Broglie wavelength: The length scale over which the system behaves coherently diverges, which is directly reflected in the shape of the spatial first order correlation function.

Using matter-wave interference we measure the correlation length of these fluctuations as a function of temperature. We study the divergence of the correlation length of the order parameter as the temperature approaches the critical point and determine its critical exponent for a trapped, weakly interacting Bose gas to be $\nu = 0.67 \pm 0.13$.

A 1.4 Mo 11:15 6J

Antibunching in einem atomaren Fermigas — •Tim Rom, Thorsten Best, Dries van Oosten, Ulrich Schneider, Simon Fölling, Belen Paredes und Immanuel Bloch — Insitut für Physik, Johannes Gutenberg-Universität, 55099 Mainz, Germany

Entartete Quantengase in optischen Gittern könnten die Realisierung von Quantenphasen, wie zum Beispiel Antiferromagnet und Supersolid, erlauben. Zum Nachweis solcher Ordnungszustände könnten Dichtekorrelationen entscheidend beitragen. Wir berichten über die Messung von Korrelationen im Schrotrauschen eines Fermigases. Dabei konnten wir erstmals antibunching an neutralen Atomen beobachten. In unserem Experiment kühlen wir fermionische Kalium-Atome in einer optischen Falle zur Quantenentartung. Die Atome werden in ein dreidimensionales optisches Gitter geladen, wo sie bei entsprechender Wahl der Gitterparameter einen Bandisolator bilden. Die Absorptionsbilder der Atomwolke nach hinreichender Expansionszeit enthalten in ihrem Schrotrauschen die Information über den ursprünglichen Ordnungszustand, die wir durch Korrelationsanalyse sichtbar machen. Wir zeigen, wie sich daraus unter anderem die Temperatur des Fermigases rekonstruieren lässt.

A 1.5 Mo 11:30 6J

Scissors Mode of a Strongly Interacting Fermi gas — •Stefan Riedl[1], Alexander Altmeyer[1], Christoph Kohstall[1], Matthew Wright[1], Johannes Hecker Denschlag[1], and Rudolf Grimm[1,2] — [1]Inst. of Experimental Physics and Center for Quantum Physics, Univ. Innsbruck, 6020 Innsbruck, Austria — [2]Inst. for Quantum Optics and Quantum Information, Acad. of Science, 6020 Innsbruck, Austria

A powerful method to investigate ultracold strongly interacting fermionic quantum gases is the study of collective excitation modes of the gas. Their behavior reveals the different regimes the gas can enter depending on the coupling between the Fermions. Here the scissors mode plays an important role since the qualitative behavior of the mode is different in a collisionless and hydrodynamic gas, respectively. Together with the low damping of the mode this allowed us to study the hydrodynamic to collisionless transition of the gas as a function of temperature. To distinguish between superfluid and collisional hydrodynamics we investigate the scissors mode in a slowly rotating trap, where the dynamic behavior of a superfluid is different compared to a normal gas.

A 1.6 Mo 11:45 6J

Coherent Control of the Superfluid-to-Mott-Insulator Transition — •Andre Eckardt and Martin Holthaus — Institut für Physik, Carl von Ossietzky Universität, 26111 Oldenburg

We demonstrate that the transition from a superfluid to a Mott-insulator in the Bose-Hubbard-Modell can be controlled coherently by an oscillating force through an effective renormalization of the tunneling matrix element [1]. The mechanism involves adiabatic following of Floquet-states in combination with diabatic passing of tiny avoided crossings in the quasienergy spectrum that indicate interaction-induced resonant coupling to excited states. Deviations from this ideal dynamics result in a loss of coherence, i.e., heating of the system. We investigate conditions for a controlled time-evolution with respect to frequency, amplitude and switching time of the drive, and discuss a possible scenario for the limit of large lattices. The estimation of experimentally accessible parameters suggests that both the regime of coherent control and its limits can be observed with ultracold atoms in optical lattices.

[1] A. Eckardt, C. Weiss, and M. Holthaus, *Superluid-Insulator Transition in a Periodically Driven Optical Lattice*, Phys. Rev. Lett. 95, 260404 (2005)

A 1.7 Mo 12:00 6J

Superradiant Rayleigh Scattering and Collective Atomic Recoil Lasing with ultracold atoms in a ring-cavity — •Sebastian Slama, Gordon Krenz, Simone Bux, Claus Zimmermann, and Philippe Courteille — Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany

We present experiments with ultracold and Bose-Einstein condensed atoms in an optical high-finesse ring cavity. This represents the first realization of BEC inside an optical resonator.

We load ultracold ^{87}Rb atoms into a ring cavity and subsequently pump one of the cavity modes. Scattering of pump light from the atoms leads to the sudden build-up of a probe light field in the non-pumped mode. The characteristic feature is the emission of a sequence of light pulses, typical for Collective Atomic Recoil Lasing (CARL)[1]. By changing the finesse of the cavity we are able to reach a regime

in which Superradiant Rayleigh Scattering (SRyS) occurs[2]. This is the first observation of cavity-enhanced SRyS. We are able to observe SRyS for temperatures as high as several tens of μK. This demontrates clearly that SRyS does not rely on quantum statistical effects, but on the cooperative behaviour of the atoms.

[1] R. Bonifacio and L. De Salvo, Appl. Phys. B 60, S233 (1995).
[2] S.Inouye et al., Science 285, 571 (1999).

A 1.8 Mo 12:15 6J

Spindomänen in F=2 87Rb Spinor-Kondensaten — •Jochen Kronjäger, Christoph Becker, Parvis Soltan-Panahi, Simon Stellmer, Kai Bongs und Klaus Sengstock — Institut für Laser-Physik, Luruper Chaussee 149 Geb. 69, 22761 Hamburg

Neue experimentelle und theoretische Untersuchungen von 87Rb Spinorkondensaten haben das grundlegende Verständnis der kohärenten Spindynamik in diesem System weit vorangebracht [1-3]. Dabei hat sich der Fokus von der semiklassischen Dynamik homogener Systeme hin zu räumlichen Effekten verschoben, die aufgrund verschiedener Mechanismen auftreten können und zu beobachtbarer Strukturbildung führen.

Spindomänen wurden bereits beobachtet in ferromagntischem F=1 87Rb [4], wo sie spontan aufgrund einer dynamischen Instabilität [5,6] auftreten. Dagegen handelt es sich bei F=2 87Rb um ein System mit antiferromagnetischem Grundzustand. Wir haben die Bildung von Spindomänen in nahezu isotroper und extrem elongierter Fallengeometrie untersucht und beobachten Strukturen auf verschiedenen charakteristischen räumlichen Skalen.

[1] M.-S. Chang et al., Nature Physics 8, 152 (2006)
[2] J. Kronjäger et al., Phys. Rev. A 72, 063619 (2005)
[3] J. Kronjäger et al., Phys. Rev. Lett. 97, 110404 (2006)
[4] L. E. Sadler at al., Nature 443, 312 (2006)
[5] W. Zhang et al., Phys. Rev. Lett. 95, 180403 (2005)
[6] J. Mur-Petit, Phys. Rev. A 73, 013629 (2006)

A 1.9 Mo 12:30 6J

Coupling a Bose-Einstein condensate to a nanomechanical resonator — •Stephan Camerer[1], David Hunger[1], Daniel König[3], Jörg Kotthaus[3], Theodor Hänsch[1], Jakob Reichel[2], and Philipp Treutlein[1] — [1]MPQ und LMU München, Deutschland — [2]LKB, ENS Paris, France — [3]LMU München, Deutschland

The experimental fusion between quantum optics and solid-state physics is a rapidly developing and auspicious field of research. Due to the capability to control atom clouds near surfaces, atom chips are particularly well suited to provide an experimental interface between a quantum optical and a condensed matter system.

Our experiment aims at studying the interaction between small Bose-Einstein condensates (BECs) and a nanomechanical resonator on an atom chip. The coupling is mediated by a single domain magnetic island located on the resonator tip. The oscillation of the thermally driven resonator is transduced by the magnetic island into an oscillating magnetic field at the location of the BEC. On resonance, the field oscillations cause spin-flip transitions of the trapped atoms: the BEC serves as quantum probe for the mechanical motion of the resonator. For high mechanical quality factors, coherent interactions between the BEC and the resonator can be studied.

The core of our experiment is a chip which combines gold wires for a magnetic trap, free-standing nanomechanical structures and single-domain ferromagnets. It is fabricated using various lithographic, deposition and etching techniques. In the talk, the current status of the experiment is reported.

A 2: Precision spectroscopy I

Zeit: Montag 10:30–12:30 Raum: 6G

Hauptvortrag A 2.1 Mo 10:30 6G

High-precision atomic physics experiments with stored and cooled ions in Penning traps — •Klaus Blaum — Gesellschaft für Schwerionenforschung GSI Darmstadt, 64291 Darmstadt, Germany — Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany

Accumulation, storing and cooling techniques for ions play an increasingly important role in many areas of science. In this respect, Penning traps have been recast as ideal tools for high-precision experiments, especially if the measurement is based on a frequency determination. Therefore, one can benefit from the existing relation between a frequency and the interesting properties, like the mass and the g-factor, of the particle to which it is related.

The presentation will concentrate on recent applications of Penning traps in the field of atomic physics at GSI Darmstadt and the University of Mainz. These are high-accuracy mass measurements, g-factor determinations of the bound-electron in highly-charged, hydrogen-like and lithium-like ions and g-factor measurements of the proton and, later, the antiproton. These experiments are dedicated *e.g.* to astrophysics studies in the case of mass measurements on radionuclides and to the determination of fundamental constants and a test of the CPT theorem in the case of g-factor measurements [1]. An overview of the three mentioned experiments and recent results will be presented.

[1] K. Blaum, Phys. Rep. 425, 1-78 (2006)

A 2.2 Mo 11:00 6G

Präzisionsspektroskopie an schnellen metastabilen Ionen für den Test der speziellen Relativitätstheorie — •C. Novotny[1], G. Huber[1], S. Karpuk[1], W. Nörtershäuser[1], S. Reinhardt[2], G. Saathoff[2], D. Schwalm[2], A. Wolf[2], G. Gwinner[3], C. Geppert[4], H.-J. Kluge[4], T. Kühl[4], M. Steck[4], T. Stöhlker[4], B. Bernhardt[5], T. W. Hänsch[5], R. Holzwarth[5] und T. Udem[5] — [1]Johannes Gutenberg-Universität Mainz — [2]MPI für Kernphysik, Heidelberg — [3]University of Manitoba, Winnipeg, Canada — [4]GSI, Darmstadt — [5]MPI für Quantenoptik, Garching

In spektroskopischen Untersuchungen an metastabilen $^7Li^+$-Ionen am Experimentier-Speicherring (ESR) der GSI konnte das Potential für einen Test des Zeitdilatationsfaktors der speziellen Relativitätstheorie aufgezeigt werden. Hierbei wurden Lithiumionen bei einer Geschwindigkeit von 34% der Lichtgeschwindigkeit mit sehr guter Strahlqualität gespeichert und es konnte gezeigt werden, dass sich der Anteil der Metastabilen im Speicherring auf 0.1% der Gesamtionenzahl beläuft [1].

Für eine Verbesserung der Signalqualität soll im nächsten Schritt die Empfindlichkeit der Signaldetektion mittels Modifikation der Spektroskopie im Speicherring erhöht sowie eine verbesserte Kontrolle der Produktion der metastabilen Ionen in der Ionenquelle erreicht werden. In diesem Experiment soll die Präzision gegenüber dem Vorgängerexperiment am Testspeicherring des MPI für Kernphysik [2] um mehr als eine Größenordnung gesteigert werden.

[1] S. Karpuk et al., Book of Abstracts of PSAS 2006, Venice, p. 60
[2] G. Saathoff et al., Phys. Rev. Lett. 91, 190403 (2003)

A 2.3 Mo 11:15 6G

Sub-Doppler cooling of magnesium by a coherent two-photon excitation — •Karsten Moldenhauer, Matthias Riedmann, Tanja E. Mehlstäubler, Jan Friebe, Nils Rehbein, André Pape, Alexander Voskrebenzev, Ernst M. Rasel, and Wolfgang Ertmer — Institut für Quantenoptik, Leibniz Universität Hannover, Deutschland

Magnesium belongs to the few elements suitable for an optical frequency standard with neutral atoms. It displays very attractive features such as a low black body radiation shift, long-lived states or the existence of magic wavelength, required for an optical lattice clock. The current stability of $8\text{x}10^{-14}$ in 1 s and spectroscopic resolution of 290 Hz is limited by the achievable temperatures of about 4 mK in a magneto-optical trap (MOT) based on the fast $^1S_0 \rightarrow {}^1P_1$ transition .

Standard Sub-Doppler cooling techniques are not applicable to Magnesium due to the absence of a magnetic sub-structure of the ground state. To surpass the Doppler-limit, we utilize a two-photon transition $^1P_0 \rightarrow {}^1D_2$ to coherently manipulate the population in $^1P_1$. This novel cooling mechanism, similar to electro-magnetically induced transparency, strongly enhances the cooling force.

Experimental results are in good agreement with our theoretical model and show temperature reductions by a factor of 10 in a 1D optical molasses and a factor of 4 in a MOT. Additional cooling times of 1 ms and atom losses below 40 % make this scheme particularly attractive to improve the short-term stability of optical frequency standards and the loading conditions into optical dipole traps for lattice clocks.

A 2.4 Mo 11:30 6G

Eine Paulfalle für die Präzessions-Laserspektroskopie an radioaktiven Berylliumionen — •Dirk Tiedemann[1], Christopher Geppert[2], Jürgen Kluge[2], Matthias Nothhelfer[1], Ferdinand Schmidt-Kaler[3], Monika Zakova[1], Claus Zimmermann[4] und Wilfried Nörtershäuser[1,2] — [1]Institut für Kernchemie, Mainz, Deutschland — [2]GSI, Darmstadt, Deutschland — [3]Abteilung für Quanten Informationsverarbeitung, Ulm, Deutschland — [4]Institut für Physik, Tübingen, Deutschland

Die Bestimmung der Kernladungsradien der leichtesten Elemente wie He, Li und Be ist für die Kernphysik von großem Interesse und stellt höchste Anforderungen an Experiment und Theorie. Um aus Messungen der Isotopieverschiebung Kernladungsradien zu extrahieren, muss der Masseneffekt mit einer relativen Genauigkeit von 10^{-5} berechnet und die Isotopieverschiebung mit einer Genauigkeit von 200 kHz bestimmt werden. Um die Isotopieverscheibung des $2s_{1/2} \rightarrow 2p_{1/2}$ Übergangs an Berylliumionen zu messen werden die Ionen nach ihrer Erzeugung in eine segementierte Paulfalle transferiert, um dort effizient gesammelt, gekühlt und spektroskopiert zu werden. Das Design der Falle ermöglicht die Anwendung und Kombination verschiedenster Kühlverfahren, großen Spielraum in der Gestaltung der Fallenpotentiale, sowie einen guten optischen Zugang für die Spektroskopie.

A 2.5 Mo 11:45 6G

Spectroscopy of Radium — •Aran Mol, Subhadeep De, Umakanth Dammalapati, Klaus Jungmann, and Lorenz Willmann — Kernfysisch Versneller Instituut, Rijksuniversiteit Groningen, 9747 AA Groningen, Niederlande

Radium has been identified as a potential candidate for experimental searches for violations of fundamental symmetries like parity (P), time reversal (T) and charge conjugation. In particular is shows a high sensitivity to T and P violating permanent electric dipole moments and also to atomic parity violation effects. This sensitivity arises from the unique atomic level scheme of radium. In the course of the setup of such experiments we need to improve the experimental data on radium.

Within the TRIμP (Trapped Radioactive Isotopes: μicro laboratories for fundamental Physics) facility at KVI, we are setting up an radioactive atomic beam of 225Ra and the laser system for performing the spectroscopy. This is guided closely by the requirements for experimental searches for symmetry violating effect.

A 2.6 Mo 12:00 6G

Hoch aufgelöste Fourier-Transformations-Spektren von Praseodym — •Bettina Gamper[1], Olivier Allard[1], Horst Knöckel[2], Eberhard Tiemann[2], Günter Guthöhrlein[3] und Laurentius Windholz[1] — [1]Institut für Experimentalphysik, Techn. Univ. Graz, Petersgasse 16, A-8010 Graz — [2]Institut für Quantenoptik, Univ. Hannover, Welfengarten 1, 30167 Hannover — [3]Fachbereich Elektrotechnik, Helmut Schmidt - Univ. der Bw Hamburg, Holstenhofweg 85, 22043 Hamburg

Die bislang vollständigste Analyse [1] des komplexen Praseodym-Spektrums basiert auf der Auswertung von Fourier-Spektren, die nicht zugänglich sind. Eine große Zahl weiterer Energieniveaus wurde durch laserspektroskopische Untersuchungen gefunden [2,3,4]. Um einerseits verbesserte Anregungswellenlängen für laserspektroskopische Untersuchungen zu bekommen und andererseits noch nicht klassifizierte Linien aufgrund ihrer charakteristischen Hyperfeinstruktur zu klassifizieren, wurden im Spektralbereich 1100 nm - 280 nm neue hoch aufgelöste Fourier-Spektren aufgenommen. Anschließende laserspektroskopische Untersuchungen im Bereich um 577,2 nm erlaubten die Aufklärung eines Dreifach-Blends. Eine weitere untersuchte Linie, die sich im Spektrum als einzelne Linie darstellt, erwies sich ebenfalls als Dreifach-Blend.

[1] A.Ginibre-Emery, Thèse, Université de Paris-Sud, (1988) [2] D.Bakkali, Diss., Universität der Bw Hamburg, (2006) [3] B.Furmann, D.Stefanska, E.Stachowska, J.Ruczkowski, J.Dembczynski, Eur. Phys. J. D 17, 275-284 (2001) [4] Z.Uddin, Diss., TU Graz, (2006)

A 2.7 Mo 12:15 6G

Relativistic Nuclear Recoil, Electron Correlation and Quantum Electrodynamic Effects in Be- and B-like Argon Ions — •Z. Harman[1], R. Soria Orts[1], A. Lapierre[1], J. R. Crespo López-Urrutia[1], U. D. Jentschura[1], A. N. Artemyev[1,2], C. H. Keitel[1], V. M. Shabaev[2], H. Tawara[1], I. I. Tupitsyn[1,2], J. Ullrich[1], and A. V. Volotka[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]St. Petersburg State University, Oulianovskaya 1, 198504 St. Petersburg, Russia

The isotope shift [1] and the radiative decay rate [2] of the $1s^2 2s^2 2p\ ^2P_{3/2} - {}^2P_{1/2}$ M1 transition and the g factor of these levels [3] in Ar^{13+} ions has been determined with high accuracy using the Heidelberg electron beam ion trap. Our isotope shift calculations are in excellent agreement with the experimental results and confirm that it is indispensable to include relativistic recoil corrections when predicting mass shift contributions in medium-Z ions. The lifetime corresponding to the above transition has been measured with an accuracy on the order of one per mil. Theoretical calculations predict a lifetime that is in significant disagreement with this high-precision experimental value. The g factor of the P states is determined with a 1.5 per mil accuracy by resolving the Zeeman components of the transition, in accordance with our theoretical results.

[1] R. Soria Orts *et al.*, Phys. Rev. Lett. 97, 103002 (2006).
[2] A. Lapierre *et al.*, Phys. Rev. Lett. 95, 183001 (2005).
[3] R. Soria Orts *et al.*, to be published

A 3: Atomic Clusters I

Zeit: Montag 10:30–12:30 Raum: 5M

Hauptvortrag A 3.1 Mo 10:30 5M

Inelastic interaction of free electrons with pristine and doped rare gas clusters — •Paul Scheier, Stephan Denifl, Fabio Zappa, Philipp Sulzer, Ingo Mähr, Andreas Mauracher, and Tilmann Märk — Institut für Ionenphysik und Angewandte Physik, Leopold-Franzens Universität, Innsbruck, Austria

Pickup of gas phase molecules including fullerenes and biomolecules into superfluid He droplets is a tool to form complex targets at ultralow temperatures (0.37 K). Free electron attachment to monomers and clusters of these molecules embedded in superfluid He droplets has been studied for the first time and exhibits several interesting features. We observe, on the one hand, stabilization of transient negative parent ions via solvation which are otherwise unstable isolated in the gas phase. On the other hand, we see an increase of the cross section of various anions at electron energies above electronic excitation of the rare gas and the embedded molecules. Extremely efficient cooling by the cold rare gas droplet can stabilize otherwise unstable intermediate reaction products and thus offers unique possibilities to identify complex molecular processes step by step. In addition to He droplets we also started experiments with pristine and doped neon clusters.

A 3.2 Mo 11:00 5M

PES Study of Silicon Doped Gold Cluster Anions — •Kiran Majer, Oleg Kostko, and Bernd v. Issendorff — Institut für Physik, Universität Freiburg, Stefan-Meier-Straße 19, 79104 Freiburg

The electronic structure of silicon doped gold cluster anions were investigated by photoelectron spectroscopy (PES). For certain cluster sizes the photoelectron spectra reveal electronic shell patterns, which can be explained within the Jellium model. Furthermore the spectral similarities between Au_N^- and $Au_{(N-4)}Si^-$ show, that the silicon dopant contributes four delocalized electrons to the cluster.

Doping noble metal cluster with impurities changes the properties of the cluster significantly. Since gold cluster have various applications in molecular electronic devices, catalysts, and biological diagnostics, there is an increasing interest to understand how the properties of nano particles can be influenced by dopant.

A 3.3 Mo 11:15 5M

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

Eine leistungsfähige Methode zur Beschreibung der Ionsisations-

dynamik von Metall-Clustern in intensiven Laserfeldern ist die zeitabhängige Simulation auf der Basis der Vlasov-Gleichung [1]. Die langreichweitige Coulombwechselwirkung der Elektronen läßt sich dabei mit einem Mean-Field-Ansatz beschreiben.
Die Erweiterung des Modells zur Einbeziehung von Elektron-Elektron-Stößen kann mit einem Vlasov-Ühling-Uhlenbeck-Schema erfolgen [2]. Bisher wurden die dazu benötigten Streuquerschnitte auf Grundlage von Thomas-Fermi-Abschirmlängen im Grundzustand des Clusters bestimmt. Im Vortrag wird ein Konzept vorgestellt, das es erlaubt, die Streuprozesse in Abhängigkeit von der Temperatur und der lokalen Dichte des Cluster-Plasmas zu ermitteln. Gezeigt wird die Auswirkung dieser Plasma-Effekte auf die Clusterdynamik.
[1] T. Fennel et al., Eur. Phys. J. D, **29**, 367 (2004)
[2] A. Domps et al., Ann. Phys., **260**, 171 (1997)

A 3.4 Mo 11:30 5M

Elektronische Eigenschaften freier Übergangsmetallcluster: Ionenausbeutespektroskopie an Vanadium-Clustern — •Jochen Rittmann[1], Marlene Vogel[1], Vicente Zamudio-Bayer[1], Thomas Möller[1], Bernd von Issendorff[2] und Tobias Lau[1] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, PN 3-1, Hardenbergstraße 36, D-10623 Berlin — [2]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg

Mit einem gepulsten Flugzeitmassenspektrometer wurde die Ionenausbeute freier Vanadiumcluster mit Größenverteilungen von etwa 20 bis einigen hundert Atomen im Bereich der Vanadium $L_{2,3}$-Kanten bei BESSY gemessen. Die Ionenausbeute ist ein Maß für die $L_{2,3}$-Röntgenabsorption.

Hochaufgelöste Ionenausbeutespektren freier Vanadiumcluster bei resonanter $2p$–$3d$ Rumpfniveauanregung geben Aufschluss über das Fragmentationsverhalten sowie über höhere Ladungszustände der Cluster. Durch die Aufnahme der Ionenausbeute in Abhängigkeit von der Anregungsenergie kann die Substruktur sowie das Verzweigungsverhältnis der $L_{2,3}$-Absorption für einzelne Clustergrößen untersucht werden. Festkörperartige Absorptionsspektren sind dabei schon bei relativ kleinen Clustergrößen ($n \approx 50$) zu beobachten.

A 3.5 Mo 11:45 5M

Winkelaufgelöste Photoelektronenspektroskopie an kleinen Natrium-Clustern — •Christof Bartels, Christian Hock, Jan Huwer, Jörg Schwöbel und Bernd v.Issendorff — Fakultät für Mathematik und Physik, Universität Freiburg, Stefan-Meier-Straße 19, 79104 Freiburg

Mit einem neu aufgebauten Bildspektrometer wurden winkelaufgelöste Photoelektronenspektren von kleinen Na_n^--Clusterionen ($n = 2 \ldots 7$) gemessen.

Natrium-Cluster aus einer Verdampfungsquelle werden negativ geladen, in einer 6 K kalten Ionenfalle thermalisiert und in einem Flugzeit-Massenspektrometer massenselektiert. Anschließend werden Elektronen aus den schwach gebundenen Zuständen durch einen ns-Laserpuls mit linearer Polarisation (Wellenlänge 290 . . . 755 nm in Schritten von 10 nm) abgelöst und auf einen Phosphorschirm projiziert.

Für diese kleinen Cluster lassen sich die besetzten Molekülorbitale als Linearkombinationen aus den Valenzorbitalen der beteiligten Atome beschreiben. Die beobachteten Übergänge können diesen Molekülorbitalen zugeordnet werden; die Entwicklung der Winkelverteilungen mit der Laserwellenlänge zeigt eine qualitative Übereinstimmung mit dem Verlauf, den man aus der Symmetrie der Orbitale erwartet.

A 3.6 Mo 12:00 5M

Winkelaufgelöste Photoelektronenspektroskopie an freien Natrium-Clustern aus 19 . . . 147 Atomen — •Christian Hock, Christof Bartels, Jan Huwer, Jörg Schwöbel und Bernd v.Issendorff — Fakultät für Mathematik und Physik, Universität Freiburg, Stefan-Meier-Straße 19, 79104 Freiburg

Mit Hilfe eines Bildspektrometers wurden winkelaufgelöste Photoelektronenspektren von negativen Natrium-Clusterionen bei Anregung mit ns-Laserpulsen (290 . . . 755 nm) aufgenommen.

Bisherige lediglich energieauflösende Photoelektronenspektren von größeren Natrium-Clustern lassen sich im Rahmen des Jelliummodells gut erklären. Dieses Modell besagt, dass die im Cluster vorhandenen Valenzelektronen in effektiven Einteilchenpotentialen behandelt werden können, wodurch sich eine ähnliche Schalenstruktur ergibt wie bei Atomen.

Die Winkelverteilung der Photoelektronen lässt sich mit Hilfe des Anisotropie-Parameters β beschreiben. Berechnet man diesen für Natrium-Cluster unter der Annahme einfacher Woods-Saxon-Potentiale, so ergeben sich charakteristische Änderungen für unterschiedliche Drehimpulszustände bei Variation der Laserenergie. Die Entwicklung dieser β-Parameter wurde für ausgewählte Clustergrößen gemessen und mit den berechneten Kurven verglichen.

A 3.7 Mo 12:15 5M

Determination of the electron effective mass in clusters — •Oleg Kostko and Bernd von Issendorff — Fakultät für Physik, Universität Freiburg, Stefan-Meier-Str. 21, 79104 Freiburg

In the bulk the electron effective mass, the inverse curvature of the dispersion curve, is strongly influenced by electron-electron and electron-lattice interactions. It is a question how this parameter changes for nanoscale particles, and how it can be determined. Here we show that this is possible for clusters with a density of states in accordance with the free electron model.

Scaling the photoelectron spectra of sodium, copper and silver clusters with similar peak distribution, one can find the relative effective masses of these elements. Solving the Schrödinger equation for sodium clusters and comparing the energy eigenvalues obtained with the electronic shells observed in the photoelectron spectra additionally allows to find absolute values of the sodium electron effective mass. The values obtained in this way are in surprisingly good agreement with the known bulk values.

A 4: Atomic Clusters II

Zeit: Montag 14:00–16:00 Raum: 6G

Hauptvortrag A 4.1 Mo 14:00 6G

Effiziente Autoionisation schwach gebundener Cluster durch Interatomaren Coulomb-Zerfall (ICD) — •Uwe Hergenhahn[1], Silko Barth[1], Volker Ulrich[1], Simon Marburger[1], Markus Lundwall[2], Gunnar Öhrwall[2] und Olle Björneholm[2] — [1]Max-Planck-Institut für Plasmaphysik, EURATOM Association, Boltzmannstr. 2, 85748 Garching — [2]University of Uppsala, Dept. of Physics, Box 530, Uppsala, SE

In den letzten Jahren hat die Autoionisation schwach gebundener Cluster großes Interesse gefunden. In diesen Systemen ist für Lochzustände in den Innervalenz-Orbitalen ein strahlungsloser Zerfall möglich, bei dem in einem nicht-lokalen Ein-Stufen-Prozess gleichzeitig die primäre Vakanz aufgefüllt und ein Elektron eines anderen Systems im Cluster ionisiert wird. Dieser Prozess ist ICD (Interatomic/-molecular Coulombic Decay) benannt worden.

Unsere Untersuchungen zeigen experimentell, dass für $2s^{-1}$ Zustände in Ne Clustern ICD der *einzige* relevante Zerfallskanal ist. Für NeAr Heterocluster wird der Zusammenhang zwischen ihrer Zusammensetzung und der Effizienz von ICD in Ne^+Ar^+ Zustände diskutiert. Als Perspektive könnte ICD zur Erforschung der Zusammensetzung unbekannter Systeme verwendet werden.

A 4.2 Mo 14:30 6G

Semiklassische Hybriddynamik für Vielteilchensysteme — •Frank Grossmann — Institut für Theoretische Physik, TU Dresden, 01062 Dresden

Basierend auf der zeitabhängigen, semiklassichen Wellenpaketpropagationsmethode von Herman und Kluk [1] kann eine semiklassische Hybridmethode abgeleitet werden, die einen Teil der Freiheitsgrade im Rahmen von einfacher Gaußscher Wellenpaketdynamik beschreibt [2]. Dieses Verfahren eignet sich besonders für komplexe Quantensysteme, die an eine Vielzahl harmonischer Freiheitsgrade gekoppelt sind. In diesem Vortrag stellen wir die Methode vor und diskutieren mögliche Anwendungen im Bereich der Atom- und Molekülphysik.
[1] M. F. Herman and E. Kluk, Chem. Phys. 91, 27 (1984)

[2] F. Großmann, J. Chem. Phys. 125, 014111 (2006)

A 4.3 Mo 14:45 6G

Magic Numbers and Superfluid Sizes in Small Para-Hydrogen Clusters — •Peter Toennies[1], Saad Khairallah[2], Mikhail Sevryuk[1], and David Ceperley[2] — [1]Max Planck Institut für Dynamik und Selbstorganisation, D-37073 Göttingen — [2]Dept. Physics, University of Illinois at Urbana-Champaign, IL 61801 USA

The Path Integral Monte Carlo method is used to study the low temperature structures and superfluidity of para-hydrogen clusters with up to 40 molecules. Clusters with sizes $N < 26$ and $T \leq 1.5$ K have nearly 100% superfluid fractions. In larger clusters superfluidity is quenched at the icosahedral-derived magic numbers $N = 26$, 29, 32, and 37 found in "classical"rare gas ion clusters, while below 1 K superfluidity is recovered for the pairs $(27, 28)$, $(30, 31)$, and $(35, 36)$ with loosely attached outer molecules. In all the clusters superfluidity is largely localized in the surface thereby explaining the apparent "supersolid"behavior discussed in the past.

A 4.4 Mo 15:00 6G

Optical properties of isomer resolved diamond clusters — •Lasse Landt[1], Christoph Bostedt[1], Kathrin Klünder[1], Thomas Möller[1], Jeremy Dahl[2], SG Liu[2], and Robert Carlson[2] — [1]Technische Universität Berlin, Germany — [2]MolecularDiamond Technologies, Richmond, CA, U.S.A.

The optical absorption of perfectly size- and structure-selected, neutral, and surface-passivated diamond clusters, so-called diamondoids, was measured in the gas phase with synchrotron radiation at beamline I of Hasylab at DESY. For this purpose a novel absorption cell for gas phase measurements in the vacuum ultraviolet spectral regime was developed. Optical absorption spectra in the energy range of 5-10 eV were recorded for nine different diamondoids, ranging in size from 10 to 26 carbon atoms, among them several isomeric structures. Our results reveal that the absorption of these subnanometer group IV semiconductor clusters depends on both size and shape. The observed isomeric dependencies will be discussed in terms of the electronic structure of the diamond clusters and compared to recent theoretical predictions.

A 4.5 Mo 15:15 6G

Harmonic generation in the laser-cluster interaction — •Mrityunjay Kundu and Dieter Bauer — Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg, Germany

Laser-atom or laser-molecule interaction typically shows higher order harmonics of the incident laser frequency. Experiments with atomic clusters, on the other hand, demonstrate the generation of low-order harmonics of higher intensity than with rare-gas atoms. By particle-in-cell (PIC) simulations of Ar_N clusters (with N up to 92096 atoms) in 800 nm, short (< 30 fs) laser pulses, we investigate why the emission is restricted to lower order harmonics. We show that the dipole radiation of the *bound* electrons and the *free* electrons counteract each other, and the resulting *destructive interference* limits the harmonics in to low orders. In this short-pulse regime the *free* electron population increases by absorbing laser energy only via the nonlinear resonance NLR [1,2]. We find that occurrence of the NLR coincides with predominant dipole radiation. However, the total dipole radiation shows enhanced third and fifth harmonic emission at times when the Mie-frequency of the ionizing and expanding cluster linearly resonates with the respective harmonics. The harmonic emission may be used to study the cluster dynamics with pump-probe experiments. By PIC simulations, we discuss a possible pump-probe experiment to predict the maximum of the cluster charge density at a given laser intensity.

[1] M. Kundu and D. Bauer, Phys. Rev. Lett., 96, 123401 (2006).
[2] M. Kundu and D. Bauer, Phys. Rev. A., 74, 063202 (2006).

A 4.6 Mo 15:30 6G

Real-time spectroscopy of photo-chemical reactions on mass-selected clusters — •Marco Niemietz[1], Kiichirou Koyasu[1], Matthias Götz[1], Markus Engelke[1], Young Dok Kim[2], and Gerd Ganteför[1] — [1]Department of Physics, University of Konstanz, 78457 Konstanz, Germany — [2]Division of Nano Sciences and Department of Chemistry, Ewha Womans University, 120-750 Seoul, Korea

The surprising catalytic properties of small nanoparticles of noble metals [1,2] motivate the research on the reaction dynamics and photochemistry of such particles. Their interaction with oxygen has been suggested to be one of the most important elementary steps in heterogenous catalysis [3]. To shed light on the underlying mechanisms, we study the dynamics of reacted Ag and Au clusters by femtosecond time-resolved photoelectron spectroscopy.

The relaxation of photo-excited $Ag_nO_2^-$ clusters with even number of atoms accompany ultrafast direct O_2 photodesorption with an unusual high quantum yield compared to the bulk. In contrast, for the odd-numbered cluster $Ag_3O_2^-$, a long-living excited state is observed, since O_2 might be dissociatively chemisorbed here.

For Au_2O^-, the time-dependent evolution of the electronic states shows evidence for a photoactivated structural transition and subsequent fragmentation via several decay channels.

[1] A. Sanchez et al., *J. Phys. Chem. A* **103**, 9573 (1999)
[2] D. C. Lim et al., *Surf. Sci.* **598**, 96 (2005)
[3] T. S. Kim et al., *J. Am. Chem. Soc.* **125**, 2018 (2003)

A 4.7 Mo 15:45 6G

Spektroskopie an Magnesium in superfluiden Heliumtropfen — •sebastian göde, andreas przystawik, josef Tiggesbäumker und k.h. Meiwes-Broer — Universität Rostock, Institut für Physik, Universitätsplatz 3, 18051 Rostock

Bei einer Düsenstrahlexpansion von Helium ins Vakuum entstehen ultrakalte Heliumtröpfchen, die beim Passieren einer Pickup-Zelle Atome aus einem Dampf niedriger Dichte aufnehmen.

Die resonante Zwei-Photonen-Spektroskopie an Magnesiumatomen zeigt, dass sich die Atome im Inneren des Tropfens befinden. Neben der Anregung des atomaren $3s3p \leftarrow 3s^2$ -Übergangs findet man bei höherer Dotierung der Tropfen einen zweiten resonanten Übergang nahe der atomaren Resonanz, der von größeren Aggregaten stammt. Während die Intensität dieses Beitrages eine starke Abhängigkeit vom Grad der Dotierung aufweist, findet man überraschenderweise keine spektrale Verschiebung als Funktion der Anzahl von Magnesiumatomen im Tropfen. Dies ist ein Hinweis darauf, dass Magnesium in superfluiden Heliumtropfen keine kompakten Cluster bildet. Der Bindungszustand der Mg-Atome im Tropfen wird diskutiert.

A 5: Precision spectroscopy II

Zeit: Montag 16:30–18:15 Raum: 6G

A 5.1 Mo 16:30 6G

Bestimmung der Ionisationsenergie von Lithium — •Wilfried Nörtershäuser[1,2], Bruce Bushaw[3], Jürgen Kluge[2,4] und Gordon Drake[5] — [1]Institut für Kernchemie, Universität Mainz — [2]GSI Darmstadt — [3]Pacific Nothwest National Laboratory, Richland WA, USA — [4]Physikalisches Institut, Universität Heidelberg — [5]University of Windsor, Ontario, Canada

Mittels Resonanz-Ionisationsspektroskopie gelang uns die bislang genaueste Bestimmung der Ionisationsenergie von Lithium. Durch eine dreifach resonante Anregung mit nachfolgender Feldionisation konnten die Rydberg Zustände der $n\ ^2P$ Serie bis zu etwa $n = 300$ vermessen werden. Schwaches Stark-Mixing durch elektrische Restfelder erlaubte auch die Anregung der $n\ ^2S$ Serie für höhere n. Darüber hinaus wurde die Isotopieverschiebung der Ionisationsgrenze zwischen ^{6}Li und ^{7}Li bestimmt. Die Resultate werden mit präzisen atomphysikalischen Berechnungen des Drei-Elektronen-Systems Lithium verglichen.

A 5.2 Mo 16:45 6G

The 2s-3s transition frequency in Lithium — •Monika Zakova[1], Kamalesh Dasgupta[3], Guido Ewald[2], Christopher Geppert[2], Matthias Nothhelfer[1], Rodolfo Sanchez[1], and Wilfried Nörtershäuser[1,2] — [1]Institut für Kernchemie, Mainz, Deutschland — [2]GSI, Darmstadt, Deutschland — [3]B.A.R.C., Bombay, Indien

We report on an absolute measurement of 2s-3s transition frequency in lithium. This measurement allows a test of theoretical calculations of

transition frequencies and isotope shifts in the three-electron system of atomic lithium. It is performed with a Ti:Sa laser at 735 nm that is stabilized to a diode laser via frequency-offset locking. The diode laser is locked to a frequency comb. Resonant excitation of the lithium atoms is detected via resonance ionization mass spectroscopy: after excitation into the 3s states, the atoms are ionized along the 3s-2p-3d-Li^+ path, mass analyzed with a quadrupole mass filter and then detected with a channeltron-type detector. These measurements will complete previous investigations of the isotope shift of all lithium isotopes.

A 5.3 Mo 17:00 6G

Ein Lasersystem für die Spektroskopie radioaktiver Be-Ionen in einer Paulfalle — Christopher Geppert[1], Jürgen Kluge[1], •Matthias Nothhelfer[2], Dirk Tiedemann[2], Ferdinand Schmidt-Kaler[3], Monika Zakova[2], Claus Zimmermann[4] und Wilfried Nörtershäuser[1,2] — [1]GSI, Darmstadt — [2]Kernchemie, Universität Mainz — [3]Quanteninformationsverarbeitung, Universität Ulm — [4]Physikinstitut, Universität Tübingen

Die Isotopieverschiebung (IV) von ^{7,9,10,11}Be soll mittels Laserspektroskopie an lasergekühlten Be^+-Ionen in einer linearen RF-Falle mit einer Genauigkeit von $\Delta\nu \approx 200$ kHz gemessen werden. Durch den Vergleich der gemessenen IV mit theoretischen Berechnungen des Masseneffektes der IV kann der Kernvolumeneffekt bestimmt und daraus der Kernladungsradius modellunabhängig auf wenige Prozent genau berechnet werden. Die radioaktiven Isotope werden on-line an ISOLDE (CERN) erzeugt und in eine RF-Falle überführt. Wir stellen ein Lasersystem für die Kühlung und Spektroskopie der Ionen im $2s_{1/2} \rightarrow 2p_{1/2}$ Übergang (313 nm) vor. Dieses besteht aus zwei Farbstofflasern mit nachfolgender Frequenzverdopplung. Einer der Laser wird direkt auf einen kommerziellen Frequenzkamm stabilisiert, während die Frequenz des zweiten Lasers durch einen RF-Offset-Lock relativ zum ersten kontrolliert wird. Mit Hilfe akusto-optischer Modulatoren kann dann rasch zwischen Kühlung und Spektroskopie gewechselt werden. Ausserdem wird ein Sprungverfahren beim Scannen angewendet, um systematische Einflüsse auf die Linienform zu vermeiden.

A 5.4 Mo 17:15 6G

A nanowire based cryogenic electron source — •Stefan Ulmer[1,3], Joseba Alonso[1,2], Klaus Blaum[1,2], Holger Kracke[1], Susanne Kreim[1], Florian Maurer[4], Wolfgang Quint[2,3], Birgit Schabinger[1], and Jochen Walz[1] — [1]Institut für Physik, Universität Mainz, 55099Mainz — [2]GSI, 64291 Darmstadt, — [3]Ruprecht-Karls-Universität, 69047 Heidelberg — [4]TU, 64287 Darmstadt, Germany

Metallic nanowires can be produced with a large length-to-diameter ratio. They show remarkable field enhancement properties. With the polymer template technique, a copper based ensemble of nanowires can be fabricated with high areal densities up to 10^7 per cm^2. Thus, such a nanowire array is suitable to be used as a field emission electron source delivering high and stable current densities at low voltages. Since the properties of the free electron gas inside the metal show weak temperature dependencies, stable field emission performance can be observed in a wide temperature range. The behavior of such a nanowire ensemble has been tested in a temperature range between 4 K and 300 K. Furthermore, in a superconducting magnet the field emission properties were tested in variable magnetic fields up to 1.9 T. In the talk the results of the measurements will be presented and discussed. One possible application of these field emission arrays are electron impact sources operated at cryogenic temperatures in high magnetic fields. In our experiment - the ultra precise measurement of the g-factor of a single isolated proton, stored in a Penning trap - we plan to use the arrays to create the charged particles under such extreme conditions.

A 5.5 Mo 17:30 6G

Nachweiselektronik zur Bestimmung des g-Faktors des Protons in einer Penning-Falle — •Holger Kracke[1], Klaus Blaum[1,2], Susanne Kreim[1], Wolfgang Quint[2], Stefan Stahl[4], Stefan Ulmer[1,3] und Jochen Walz[1] — [1]Institut für Physik, Universität Mainz, 55099 Mainz, — [2]GSI, 64291 Darmstadt, — [3]Ruprecht-Karls-Universität, 69047 Heidelberg, — [4]Stahl-Electronics, 67582 Mettenheim, Germany

Ein einzelnes geladenes Teilchen, das in einer Penning-Falle gefangen ist, kann über die in den Fallenelektroden induzierte Spiegelladung nicht-destruktiv nachgewiesen werden. Im hier vorgestellten Experiment wird beabsichtigt, die Bewegung eines Protons auf diese Weise zu detektieren, woraus der g-Faktor bestimmt werden kann. Die Falle bildet zusammen mit einer Spule einen LC-Schwingkreis, dessen Resonanzfrequenz mit der Bewegungsfrequenz des Protons übereinstimmen muss. Die an der Impedanz abfallende Spannung wird detektiert, wobei die Signalstärke proportional zur Güte des Schwingkreises ist. Um eine hohe Güte zu erreichen, wird eine supraleitende Spule in einem supraleitenden Gehäuse verwendet. Die Platzierung der Spule und der Verstärkereinheit im kryogenen Bereich bei 4 K, in der Nähe der Signalquelle, reduziert das thermische Rauschen und zusätzliche Störungen. Mit dem hierdurch erreichten Signal/Rausch-Verhältnis ist es möglich den Strom, den ein einzelnes Proton induziert, zu messen. Im Vortrag werden Untersuchungen zu den Eigenschaften von Zylinderluftspulen präsentiert. Insbesondere werden die gütelimitierenden Verlustmechanismen und Methoden zu deren Reduktion diskutiert.

A 5.6 Mo 17:45 6G

Progress towards a direct measurement of the proton g-factor in a double Penning trap — •Susanne Kreim[1], Klaus Blaum[1,2], Holger Kracke[1], Wolfgang Quint[2], Stefan Stahl[4], Stefan Ulmer[1,3], and Jochen Walz[1] — [1]Institut für Physik, Universität Mainz, 55099 Mainz — [2]GSI, 64291 Darmstadt — [3]Ruprecht-Karls-Universität, 69047 Heidelberg — [4]Stahl-Electronics, 67582 Mettenheim, Germany

Determining the g-factor of a single, isolated proton in a double Penning trap setup results from an accurate measurement of its cyclotron and spin precession frequency. The latter can be determined by inducing radio frequency transitions between the two spin states in the homogeneous magnetic field region of the first, precision Penning trap. The resulting spin state is detected in another region, namely the magnetic bottle field of the analysis trap. There, the spin direction is monitored by measuring the respective axial frequency via the continuous Stern-Gerlach effect. This experiment is performed in a 4K cryogenic environment providing an ultra-high vacuum as well as long storage times of the particle. These surroundings bear great challenges for the electronics needed to non-destructively detect the trapped proton. However, it leads to a low Johnson noise of the detection electronics. Together with the use of superconducting alloys, which lead to a high Q-value of the resonant coil, the signal-to-noise ratio can be improved by some orders of magnitude enabling measurements with a very low uncertainty. The sealed system also calls for an in-trap creation of protons with a newly developed cryogenic electron gun.

A 5.7 Mo 18:00 6G

Towards a g-factor determination of the bound electron in highly-charged calcium ions — •Birgit Schabinger[1], Joseba Alonso[1,2], Klaus Blaum[1,2], Jürgen Kluge[2,3], Wolfgang Quint[2], Stefan Stahl[4], Manuel Vogel[2], and Günter Werth[1] — [1]Institute of Physics, Johannes Gutenberg-University, 55099 Mainz, Germany — [2]GSI Darmstadt, 64291 Darmstadt, Germany — [3]Ruprecht-Karls-University, 69047 Heidelberg, Germany — [4]Stahl-Electronics, 67582 Mettenheim, Germany

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

[1] W.Werth *et al.*, Int. J. Mass Spec. **251**, 152 (2006)
[2] M. Vogel *et al.*, Nucl. Inst. Meth. B **235**, 7 (2005)
[3] J. Alonso *et al.*, Rev. Sci. Instr. **77**, 03A901 (2006)

A 6: Interaction with strong laser pulses I

Zeit: Montag 16:30–18:30 Raum: 5M

Hauptvortrag A 6.1 Mo 16:30 5M

Quantum mechanics without wavefunction - a density functional perspective on electron dynamics — •Stephan Kümmel — Physikalisches Institut, Universität Bayreuth, D-95440 Bayreuth

The non-linear and non-perturbative electron dynamics which can be triggered in atoms and molecules, e.g., by the fields of intense lasers, is hard to describe quantum-mechanically due to the enormous computational effort that is associated with solving the time-dependent many-particle Schrödinger equation. Time-dependent density functional theory, i.e., the alternative formulation of quantum mechanics that does not need the many-particle wavefunction, offers a computationally inexpensive and therefore attractive alternative. Since the theory is formulated in terms of simple, intuitively accessible quantities - the particle density and a local effective potential - it frequently allows to gain a direct understanding of observed physical processes. One example for this is the calculation and understanding of the response properties of extended molecular systems. The ultimate strength of time-dependent density functional theory, however, lies in the possibility to access non-perturbative dynamics. This will be demonstrated for the strong-field double ionization of the Helium atom.

A 6.2 Mo 17:00 5M

Visualisierung der Kernwellenpaketsdynamik von H2 (D2) in und mit intensiven Laserpulsen — •Thorsten Ergler[1], Artem Rudenko[1], Bernold Feuerstein[2], Karl Zrost[1], Claus Dieter Schröter[1], Robert Moshammer[1] und Joachim Ullrich[1] — [1]Max Planck Institut für Kernphysik, 69117 Heidelberg, Deutschland — [2]Universität Heidelberg, 69120 Heidelberg, Deutschland

Mit der so genannten "Coulomb Explosion Imaging" Technik ist es möglich die Bewegung der Kerne von einfachen Molekülen abzubilden bzw. Kernwellenpakete auf einer Zeitskala von einigen Femtosekunden abzutasten. Zur Abbildung der Wellenpaketsdynamik gebundener molekularer Zustände benötigt man Laserpulse, die deutlich kurzer sind als die molekulare Vibrationszeit Tv. Für H2, dem einfachsten Molekül mit Tv=16 fs, sind somit Laserpulse von sub-10 fs nötig. In Pump-Probe Experimenten mit 7 fs Pulsen ist es uns nun erstmals gelungen die zeitliche Entwicklung des H2+ (D2+)-Kernwellenpakets in Raum und Zeit zu verfolgen und zu visualisieren. Eine Fourieranalyse der experimentellen Daten liefert Informationen über die Zusammensetzung des im Pump-Puls erzeugten Wellenpakets. Des Weiteren konnte ein Grundzustandswellenpaket durch einen intensiven, 6-7 fs Laserpuls im neutralen D2-Molekül angeregt werden. Durch die Beobachtung dieser Oszillation in der Zeitdomäne war es möglich, die Phasenlage dieser Schwingung zu bestimmen und so den vor kurzem vorgeschlagenen "Lochfrass"-Anregungsmechanismus als dominanten Prozess zu identifizieren.

A 6.3 Mo 17:15 5M

Nichtsequentielle Doppelionisation von H_2 in starken Laserfeldern — •Silvio Baier[1], Camilo Ruiz[1], Luis Plaja[2] und Andreas Becker[1] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden — [2]Departemento de Fisica Aplicada, Universidad de Salamanca, 37008 Salamanca, Spain

Nichtsequentielle Doppelionisation von Atomen und Molekülen in starken Laserfeldern ist Gegenstand umfangreicher theoretischer und experimenteller Analysen. Wir haben zur Doppelionisation von H_2 ab-initio-Rechnungen in reduzierter Dimensionalität durchgeführt. Dabei wurde die Position der Kerne festgehalten sowie die Schwerpunktskoordinate der beiden Elektronen auf die Polarisationsachse beschränkt, während die Relativbewegung vollständig berücksichtigt wurde. Anhand der numerischen Ergebnisse war es möglich, verschiedene Beiträge zur nichtsequentiellen Doppelionisation zu identifizieren und charakterisieren [1]. Die Abhängigkeit der Ergebnisse von der Orientierung der Molekülachse zur Polarisationsachse werden vorgestellt und mit experimentellen Ergebnissen [2] verglichen.

[1] S. Baier et al., Phys. Rev. A 74, 033405 (2006)
[2] D. Zeidler et al., Phys. Rev. Lett. 95, 203003 (2005)

A 6.4 Mo 17:30 5M

Relativistic recollisions with two consecutive laser pulses — •Mario Verschl and Christoph H. Keitel — Max-Planck Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

A novel scheme is introduced which allows for relativistic, laser-driven electron core recollisions with energies up to the high-energy regime. An electron is separated from the core by means of an intense laser pulse. The driving mechanism is the electron drift occurring in intense, propagating laser fields. A second laser pulse drives the electron back for recollision with the core. The relative intensity of these two pulses can be tuned such that the maximal kinetic energy an electron can reach in a propagating laser field, is reached at the instant of recollision.

The efficiency of collisions can be increased by reversing wave packet spreading before the electron returns to the core. This can be accomplished by means of a magnetic field pulse which has to be applied between the laser pulses. With the correct timing, the wave packet reaches its minimal spatial extension when it collides with the core. Thus efficient relativistic recollisions become feasible.

A 6.5 Mo 17:45 5M

Microscopic laser-driven electron-positron colliders — •Carsten Müller, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

We present an alternative concept of a laser-driven electron-positron collider [1]. High luminosities are achieved by employing a gas of positronium atoms instead of electron and positron beams. As an example, the process of muon pair creation from electron-positron annihilation in a laser field is discussed [2].

[1] K. Z. Hatsagortsyan, C. Müller, and C. H. Keitel, Europhys. Lett. 76, 29 (2006)
[2] C. Müller, K. Z. Hatsagortsyan, and C. H. Keitel, Phys. Rev. D 74, 074017 (2006)

A 6.6 Mo 18:00 5M

e^+e^--Paarbildung in starken, gegenläufigen Laserfeldern — •Guido R. Mocken, Matthias Ruf, Carsten Müller, Karen Z. Hatsagortsyan und Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Eine der interessantesten Vorhersagen der Dirac-Theorie stellt die Elektron-Positron-Paarbildung in einem elektrischen Feld oberhalb der kritischen Feldstärke $E_c = m_e^2c^3/(\hbar e)$ dar [1]. Weder mit statischen Feldern noch mit den heutigen Lasersystemen ist diese Feldstärke derzeit erreichbar, jedoch ist eine Beobachtung von Paarbildungsprozessen im nichtperturbativen Multiphotonbereich auch bei niedrigen Intensitäten vielversprechend. Ein mögliches Szenario ist das Feld zweier starker, gegenläufiger Laser, welches näherungsweise als oszillierendes, rein elektrisches Feld angesehen werden kann und dann die Aufstellung eines gewöhnlichen Differentialgleichungssystems für die Wahrscheinlichkeitsamplituden von Elektronen positiver und negativer Energie gestattet [2]. Während eine analytische Behandlung nur näherungsweise möglich ist [2, 3], erlaubt die numerische Integration [3] eine exakte Lösung und beispielsweise eine detaillierte Analyse der Frequenzabhängigkeit der Paarbildungwahrscheinlichkeit sowie, im resonanten Fall, der zu beobachtenden Rabi-Oszillationen zwischen Elektronzuständen positiver und negativer Energie.

[1] J. Schwinger: Phys. Rev. 82, 664 (1951).
[2] H. K. Avetissian et al.: Phys. Rev. E 66, 016502 (2002).
[3] K. Z. Hatsagortsyan, G. R. Mocken, M. Ruf, C. Müller und C. H. Keitel: in Vorbereitung.

A 6.7 Mo 18:15 5M

Dipole-forbidden transitions of nuclei interacting with super-intense laser fields — •Adriana Pálffy[1], Thomas J. Bürvenich[2], Jörg Evers[1], and Christoph H. Keitel[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Frankfurt Institute for Advanced Studies

With present and upcoming light sources, the direct interaction between nuclei and super-intense laser fields has become feasible, opening the new field of nuclear quantum optics [1]. While for atomic systems the dipole transition is playing the most important role [2], in the case of nuclei, which present rich structural properties like collective and single-particle excitations, mostly dipole-forbidden transitions occur. The spectrum of E1 transitions is limited to few low-lying nuclear excited states with small reduced transition probabilities, and giant res-

onances, at energies of several MeV, which are not directly accessible nowadays with the laser. We investigate dipole-forbidden transitions of nuclei interacting with super-intense laser fields, considering several stable nuclei with suitable first excited states. The strong reduced transition probabilities and the suitable energy values make E2 and M1 nuclear transitions good candidates for the resonant interaction between nuclei and laser fields. As an ultimate goal, one may hope that direct laser-nucleus interactions could become a versatile tool to enhance preparation, control and detection in nuclear physics.

[1] T. J. Bürvenich, J. Evers, and C. H. Keitel, Phys. Rev. Lett. 96, 142501 (2006).

[2] M. O. Scully and M. S. Zubairy, Quantum Optics (Cambridge).

A 7: Ultracold Plasmas and Rydberg Dynamics (jointly with Q)

Zeit: Dienstag 10:30–12:15 Raum: 5M

Hauptvortrag A 7.1 Di 10:30 5M

Rydberg atom and molecule optics — •Frederic Merkt, Edward Vliegen, and Stephen Hogan — ETH Zurich, Zurich, Switzerland

Recent experiment are reviewed in which the velocity distributions of Rydberg atoms and molecules have been influenced by the use of inhomogeneous fields. The experiments rely on the very large dipole moments exhibited by Rydberg Stark states and the large forces that can be applied on the particles by inhomogeneous electric fields. Typical experiments rely on the photoexcitation of cold atoms and molecules in skimmed supersonic beams to Rydberg Stark states. When propagating through regions of space in which inhomogeneous electric fields are applied, the particles are subject to strong forces [1]. Carefully designed electrode configurations enable the application of very large forces. By optimizing the time dependence of the applied electric fields the forces applied on the atoms can be adapted to the instantaneous positions of the particles [2,3]. Based on these principles, we have realised several devices such as Rydberg atom deflectors [1], accelerators and decelerators [1-4], a Rydberg atom mirror [5], and two-dimensional and three-dimensional traps for Rydberg atoms and molecules.

[1] S. R. Procter, Y. Yamakita, F. Merkt and T. P. Softley, Chem. Phys. Lett. 374, 667 (2003) [2] E. Vliegen, H.J. Woerner, T.P. Softley and F. Merkt, Phys. Rev. Lett. 92, 033005 (2004) [3] E. Vliegen and F. Merkt, J. Phys. B 38, 1623 (2005) [4] E. Vliegen and F. Merkt, J. Phys. B 39, L241 (2006) [5] E. Vliegen and F. Merkt, Phys. Rev. Lett. 97, 033002 (2006)

Fachvortrag A 7.2 Di 11:00 5M

Rydberg excitation in the strong blockade regime: from thermal cloud to BEC — •Vera Bendkowsky[1], Rolf Heidemann[1], Ulrich Raitzsch[1], Björn Butscher[1], Helmar Bender[1], Robert Löw[1], Luis Santos[2], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart — [2]Institut für Theoretische Physik, Universität Hannover, Appelstraße 2, 30167 Hannover

The van der Waals interaction of Rydberg atoms can - depending on the atomic density and the excitation strength - lead to a supression of Rydberg excitation in a cloud of ground state atoms. In this blockade regime the atomic sample can be considered as consisting of many blockade spheres with N ground state atoms within a sphere but only one excited Rydberg atom.

In our experiments we excite magnetically trapped Rubidium atoms at temperatures between a few μK and BEC to the 43S state. In the thermal cloud we observe saturation in the Rydberg excitation for a large range of densities and Rabi frequencies Ω_0. As expected for coherent collective excitation of any mesoscopic system the initial excitation rate is proportional to $\sqrt{N}\Omega_0$. The scaling of the saturation value is investigated with respect to N and Ω_0.

Furthermore we present first results on Rydberg excitation in a BEC. The measurements show a clear signature of Rydberg excitation within the BEC. The results are compared with a mean field calculation for the quantum dynamics above and below T_c.

A 7.3 Di 11:30 5M

Observation of Rabi cycles and coupling to continuum states in the excitation of a mesoscopic cloud of cold atoms to Rydberg levels — •Markus Reetz-Lamour, Thomas Amthor, Johannes Deiglmayr, Sebastian Westermann, Janne Denskat, and Matthias Weidemüler — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, D-79104 Freiburg

Ultracold Rydberg gases are a possible candidate for quantum information processing combining the coherence properties of ground state atoms with strong Rydberg-Rydberg interaction for fast quantum gates [1]. While the coherent character of Rydberg-Rydberg interaction has been confirmed in a number of experiments [2], the realization of q-bits itself turned out to be rather challenging.

We will present the experimental ingredients to drive Rabi cycles between the electronic ground states and Rydberg states in a mesoscopic cloud of ∼100 laser-cooled ^{87}Rb atoms, which is the essential ingredient for constructing qbits with Rydberg atoms. We will also show how this coherent excitation can be used to study coupling to a quasi-continuous large subset of Rydberg states. This leads to effects very similar to Fano resonances.

[1] Jaksch *et al.*, PRL **85**, 2208 (2000), Lukin *et al.*, PRL **87**, 037901 (2001)

[2] *E.g.* Anderson *et al.*, PRA **65**, 063404 (2002), Westermann *et al.*, EPJ D **40**, 37 (2006)

A 7.4 Di 11:45 5M

Simulating the dynamics of strongly coupled many-particle plasmas at low temperatures. — •Michael Bussmann[1], Ulrich Schramm[2], and Dietrich Habs[1] — [1]Department f. Physik, Ludwig-Maximilians-Universität Muenchen, Am Coulombwall 1, 85748 Garching — [2]Forschungszentrum Dresden Rossendorf, Bautzner Landstraße 128, 01328 Dresden

The dynamics of strongly coupled plasmas at mK temperatures are studied for the special case of stopping highly charged ions in a laser cooled plasma of $N = 10^5$ $^{24}Mg^+$ ions [1].
Using a parallel simulation code the stopping process is studied with respect to stopping times, plasma stability and recooling efficency [2]. It is shown that the proposed cooling scheme is feasible for cooling highly charged rare ions to mK temperatures without suffering from ion loss due to charge exchange.
In the outlook we present examples of simulations of strongly coupled plasmas in beam and trap physics illustrating the capabilities of the simulation with regard to investigating many-particle systems at low temperatures.

[1] M. Bussmann, U. Schramm, V. Kolhinen, J. Szerypo, D. Habs, *Int. J. of Mass Spectrometry* **251** (2006) 179-189
[2] M. Bussmann, U. Schramm, D. Habs, *AIP Conference Proceedings* **862** (2006), 221-231

A 7.5 Di 12:00 5M

Ultracold negative ions — •Jan Meier — Max-Planck-Institut für Kernphysik, Postfach 103980, 69029

Currently no technique exists which allows the cooling of negative ions to a temperature lower than that of the surrounding trap. Laser cooling of negative osmium ions holds the prospect of achieving temperatures well below 1 mK. Cooling antiprotons with this technique might open the door to forming antihydrogen at ultra-cold temperatures, thus allowing precision antimatter studies.

A 8: Precision Spectroscopy III

Zeit: Dienstag 14:00–16:00 Raum: 6G

Hauptvortrag A 8.1 Di 14:00 6G

Antihydrogen studies with ATHENA — •Alban Kellerbauer — Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg

The ATHENA experiment at CERN was the first to produce cold antihydrogen atoms in 2002 by mixing antiprotons and a positron plasma. During the following years, the antihydrogen formation processes and the properties of the produced anti-atoms were studied in detail. The setup of the experiment will be briefly reviewed and the most recent results presented.

A 8.2 Di 14:30 6G

Relativistic coupled-cluster theory of parity non-conservation in atomic systems — •Bijaya Kumar Sahoo — Max-Planck institute for the physics of complex systems

Our present understanding of elementary particle physics is encapsulated in the Standard Model (SM). Despite the remarkable success of this model, it is assumed as an intermediate manifestation of a complete theory. Parity non-conservation (PNC) in atomic systems which arises primarily from the neutral weak interaction between the electrons, and the nucleus has the potential to probe new physics beyond the SM. By combining the results of high precision measurements, and many-body calculations of atomic PNC observables, it is possible to extract the nuclear weak charge (Q_W), and compare with the corresponding value in the SM. A discrepancy between these two values could reveal the possible existence of new physics. We shall demonstrate application of the full fledged relativistic coupled-cluster theory which incorporates all the single,double and leading triple excitations to calculate parity non-conserving E1 amplitude in Ba^+.

A 8.3 Di 14:45 6G

The HITRAP Cooler Trap: simulation of cooling of highly-charged ions in a Penning trap with a Particle-In-Cell code — •Giancarlo Maero[1], Frank Herfurth[1], Oliver Kester[1], Jürgen Kluge[1], Stephen Koszudowski[1], Wolfgang Quint[1], Stefan Schwarz[2], and Günter Zwicknagel[3] — [1]GSI Darmstadt, Germany — [2]MSU, East Lansing, USA — [3]Universität Erlangen, Germany

In the HITRAP facility heavy and highly-charged ions up to U^{92+} will be stopped and cooled in order to perform experiments on atomic properties, like collision studies, precision measurements and hyperfine spectroscopy. The Cooler Trap is designed to catch 10e5 particles, cool them down to 4 K and manipulate them before extraction in both pulsed and quasi-continuous modes. Therefore simulation of the dynamics of the bunch from injection to extraction is necessary. The processes occurring during the 10 s stay of the ions in the Penning trap, all of which need a numerical investigation, are particle cloud formation in the presence of space charge, electron and resistive cooling. We give an overview of the setup and show the results obtained with a PIC (Particle-In-Cell) code built for this purpose.

A 8.4 Di 15:00 6G

Mass measurements with SHIPTRAP in the endpoint-region of the rp-process — •Ana Martín[1], D. Ackermann[1], M. Block[2], A. Chaudhuri[3], S. Eliseev[1], F. Herfurth[1], F.P. Hessberger[1], S. Hofmann[1], H.-J. Kluge[1], G. Maero[1], J.B. Neumayr[4], W. Plass[5], C. Rauth[1], L. Schweikhard[3], P.G. Thirolf[4], and G. Vorobjev[1] — [1]GSI — [2]NSCL — [3]Universität Greifswald — [4]Universität München — [5]Universität Gießen, for the SHIPTRAP collaboration.

SHIPTRAP works nowadays as a precision Penning trap mass spectrometer for the products of the fusion-evaporation reactions generated at the velocity filter SHIP at GSI. The fusion evaporation residues are stopped in a helium-gas filled stopping cell. The ions are guided by an extraction RFQ structure, and enter an RFQ buncher for accumulation and cooling. The generated bunch of ions is later injected in the double Penning trap system placed in a superconducting magnet of 7 T. The first trap is dedicated to the isobaric selection of the sample and the second one to the mass measurement using the TOF-ICR method.

Mass measurements can help determining nucleo-synthesis paths if the uncertainty of the mass measurement is no larger than 10 keV for the waiting point nuclei. In February 2006, two runs took place at SHIPTRAP in order to study the end point region of the rp-process. A target of ^{58}Ni was irradiated with a ^{58}Cr beam during the first run and a ^{58}Ni beam during the second one. The masses of 24 isotopes in the ^{100}Sn region were determined with relative uncertainties between $1 \cdot 10^{-7}$ and $5 \cdot 10^{-8}$.

A 8.5 Di 15:15 6G

Status von HITRAP und Planung der Inbetriebnahme* — •Oliver Kester[1], Klaus Blaum[2], Sergey Eliseev[1], Frank Herfurth[1], Heinz-Jürgen Kluge[1], Christophor Kozhuharov[1], Stephen Koszudowski[1], Giancarlo Maero[1], Wolfgang Quint[1], Alexey Sokolov[1], Thomas Stöhlker[1], Gleb Vorobjev[1], Manuel Vogel[1], Danyal Winters[1], Wilfried Nörtershäuser[2] und Ludwig Dahl[1] — [1]GSI Darmstadt, Planckstrasse 1, D-64291 Darmstadt — [2]Institut für Physik, Uni-Mainz, Staudingerweg 7, 55128 Mainz

Das HITRAP Projekt zum Abbremsen, Einfangen und Kühlen höchstgeladener Ionen an der GSI, befindet sich im Aufbau im Re-Injektionskanal zwischen Experimentierspeichering (ESR) und Schwerionensynchrotron (SIS). Ziel des Projektes sind Experimente mit intensiven, gekühlten Strahlen von extrem hochgeladenen Ionen bis zu Uran 92+ bei niedrigen Energien. Die Experimente an HITRAP umfassen unter anderem Präzisions- und Laserspektroskopie, neuartige Studien zur Wechselwirkung von Ionen mit Oberflächen, sowie Stossexperimente mit vollständiger kinematischer Analyse. Nachdem die Berechnungen der Strahldynamik und der HF-Eigenschaften der Linearbeschleunigerstrukturen in 2006 fertiggestellt wurden, sind sämtliche Komponenten der Strahllinie in der Fertigung oder z.T. an die GSI ausgeliefert worden. Die erste Sektion des Linearbeschleunigers soll in einer Teststrahlzeit im Mai 2007 in Betrieb genommen werden.

A 8.6 Di 15:30 6G

Eine Penningfalle für die Präzisions-Laserspektroskopie an hochgeladenen Ionen — •Jörg Krämer[1], Zoran Andjelkovic[1], Christopher Geppert[2], Manuel Vogel[2], Danyal Winters[2] und Wilfried Nörtershäuser[1,2] — [1]Johannes Gutenberg Universität Mainz, Deutschland — [2]GSI Darmstadt, Deutschland

Mit Hilfe der Speicherung in einer kryogenen Penning-Falle soll Laserspektroskopie an Hyperfeinstruktur-Übergängen in hochgeladenen Ionen mit einer relativen Auflösung $\Delta\nu/\nu$ von 10^{-7} durchgeführt werden. Dies erlaubt Tests der QED auf dem Prozent-Niveau. Wir präsentieren eine zylindrische Penningfalle, die speziell für diesen Zweck entwickelt wurde und stellen off-line Testmessungen vor. Später sollen hochgeladene Ionen, wie etwa $^{207}Pb^{81+}$ an HITRAP an der GSI Darmstadt erzeugt und in diese Falle überführt werden. Es ist vorgesehen, etwa 10^5 dieser Ionen in die Falle einzufangen und auf Temperaturen von etwa 4 K zu kühlen. Dadurch kann die Dopplerverbreiterung der Resonanzlinien auf einige 10 MHz in etwa 10^{14} reduziert werden, was die geplanten Messungen zwei Größenordnungen präziser macht als alle vorangegangenen. Ebenso verwendet diese Falle eine "rotating wall"-Technik zur Kompression der gespeicherten Ionenwolke; damit werden Dichten von bis zu 10^9 Ionen pro Kubikzentimeter erreicht und entsprechend hohe Signal-zu-Rausch-Verhältnisse des Fluoreszenzlichts.

A 8.7 Di 15:45 6G

Test of a Penning Trap dedicated for Laser Spectroscopy of Highly Charged Ions — •Zoran Andjelkovic[1], Christopher Geppert[2], Jörg Krämer[1], Manuel Vogel[2], and Wilfried Nörtershäuser[1,2] — [1]Nuclear Chemistry, University of Mainz, Germany — [2]GSI, Darmstadt, Germany

Precision hyperfine structure measurements of highly charged ions are planed using a cryogenic Penning trap. Ions like $^{207}Pb^{81+}$, produced at the HITRAP at GSI Darmstadt, will be trapped and cooled down to temperatures of about 4 K via resistive cooling. Thus the Doppler broadening of the resonance lines can be reduced to some 10 MHz in a transition frequency of some 10^{14} Hz, which makes the planned measurements roughly two orders of magnitude more precise than all previous ones. We present the experimental setup for laser spectroscopy and first test measurements with $^{40}Ca^+$ ions where we operate the trap as an RF trap, as well as detection methods that will be applied.

A 9: Interaction with strong laser pulses II

Zeit: Dienstag 14:00–16:00 Raum: 5M

Hauptvortrag A 9.1 Di 14:00 5M

Correlated electron dynamics in few-cycle pulses — •Andreas Becker — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, D-01187 Dresden

Electron correlation consitutes a basic resource for the understanding of the dynamics of many-particle systems. Its relevance becomes particular obvious in the double ionization by intense Ti:sapphire laser radiation (for a review see e.g. [1]). We have recently analyzed the ionization of two-electron atoms [2] and molecules [3] using ab-initio simulations beyond the conventional one-dimensional approximation. In the model [2] the electron correlation is included in its full dimensionality, while the center-of-mass motion is restricted along the polarization axis. The analysis of the numerical results reveals two pathways of non-sequential double ionization, namely the emission of a highly correlated electron pair and the ionization of previously excited ions, which are both linked to the return of an initially singly ionized electron wave packet to the residual ion.

[1] A.Becker et al., J. Phys. B **38** (2005) S753
[2] C.Ruiz et al., Phys. Rev. Lett. **96** (2006) 053001
[3] S.Baier et al., Phys. Rev. A **74** (2006) 033405

A 9.2 Di 14:30 5M

Molecular tomography: test of accuracy and improvements using time-dependent calculations — •Elmar van der Zwan[1] and Manfred Lein[2] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Deutschland — [2]Institut für Physik, Universität Kassel, Deutschland

Recently a method to perform tomographic imaging of molecular orbitals using High Harmonic Generation (HHG) has been proposed [1]. The method is based on the simplification that the returning electron in the three-step model can be modeled as a plane wave. We investigate the effect of this assumption in a time-dependent calculation by numerically comparing results for the final reconstructed orbital using two different methods which, without the plane-wave assumption, should lead to identical results; namely the reconstruction based on dipole matrix elements or on momentum matrix elements. An error reduction scheme is developed to post-process the results. Using *a priori* constraints like compactness and realness of the orbital, and knowledge about the type of error introduced, we can remove a large part of the error. We present results for molecules with both anti-symmetric and asymmetric valence orbitals, as they cause problems in the original scheme.

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

A 9.3 Di 14:45 5M

Ionisation von Atomen mit Lichtpulsen aus einem 6 MHz Laseroszillator — •Sebastian Tschuch[1], Yunquan Liu[1], Martin Dürr[1], Robert Moshammer[1], Joachim Ullrich[1], Martin Siegel[2] und Uwe Morgner[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Leibniz-Universität Hannover, Welfengarten 1, 30167 Hannover

Durch innovative Laserkonzepte ist es heutzutage möglich Intensitäten von $10^{14} - 10^{15}$ W/cm^2 direkt mir einem Laseroszillator zu erzeugen. Im Vergleich zu verstärkten Lasersystemen ergibt sich eine um 3 Großenordnungen höhere Pulswiederholrat [1]. Diese Lichtquelle macht Ionisationsexperimente bei kleiner Ereigniswahrscheinlichkeit möglich und erschließt somit einen interessanten Intensitätsbereich, der durch den Übergang von der Multiphotonenionisation zur Feldionisation beschrieben werden kann. Von besonderem Interesse ist dabei das Verhalten der nichtsequenziellen Doppelionisation, so sagt z.B. das semiklassische "recollision model" eine Intensitätsschwelle vorher. Im Beitrag werden erste Ergebnisse eines neuen Versuchaufbaus diskutiert.

[1] S. Dewald et. al., Opt.Lett. 31 (2006), 2072

A 9.4 Di 15:00 5M

Coulomb effects in strong-field ionization — •Sergei Popruzhenko — Max-Planck-Institut für Kernphysik, Postfach 10 39 80, 69029 Heidelberg, Germany

Recent high-resolution experiments with atoms subjected to short intense laser pulses have generated new interest to the role of long-range atomic field in the ionization dynamics. Here we present a new method of including Coulomb effects in the description of the strong field ionization. The approach is based on the Kapitza method of separation the classical electron dynamics into fast oscillations and slow-varying motion. The method is applied for description of the Coulomb peculiarities in above-threshold ionization (ATI) spectra. In particular, the cusp and the double-hump structures in the photoelectron momentum distribution in a linearly polarized field, as well as the fourfold symmetry violation of the angular distributions with elliptical laser polarization are reproduced in good agreement with the data. Besides, the method gives an insight into the problem: why do Coulomb effects in ATI spectra remain quite pronounced even in the strong-field limit? Basically, this feature results from the fact that relatively weak but slow-varying Coulomb force induces an accumulating effect which can survive after averaging over many laser periods.

A 9.5 Di 15:15 5M

Plasmon-enhanced multiple ionization C_{60} in intense short pulse laser fields down to 9 fs — •Ihar Shchatsinin, Tim Laarmann, Gero Stibenz, Günter Steinmeyer, Andrei Stalmashonak, Nickolai Zhavoronkov, Claus Peter Schulz, and Ingolf Volker Hertel — Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy, Max-Born-Str. 2A 12489 Berlin-Adlershof, Germany

The interaction of C_{60} fullerenes with 800 nm laser pulses as short as 9 fs at intensities up to 4×10^{14} Wcm^{-2} is investigated with photoion spectroscopy. The excitation time lies well below the characteristic time for electron - electron and electron - phonon coupling. Thus, energy deposition into the system is much shorter than the energy redistribution among the various electronic and nuclear degrees of freedom. The observations indicate that for final charge states $q > 1$ the C_{60} giant plasmon resonance is involved in the absorption process and a significant amount of large fragments is created through non-adiabatic multi-electron dynamics (NMED) even with 9 fs pulses [1]. In contrast, singly charged ions are generated by an essentially adiabatic single active electron mechanism (SAE) and negligible fragmentation is found when 9 fs pulses are used. These findings promise to unravel a long standing puzzle in understanding C_{60} mass spectra generated by intense fs laser pulses.

[1] I. Shchatsinin, T. Laarmann, G. Stibenz, G. Steinmeyer, A. Stalmashonak, N. Zhavoronkov, C. P. Schulz and I. V. Hertel, J. Chem. Phys. 125 (2006) 194320/1-15

A 9.6 Di 15:30 5M

Nonsequential double recombination in intense laser fields — Peter Koval, Florian Wilken, •Dieter Bauer, and Christoph Keitel — Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg

A second plateau in the harmonic spectra of laser-driven two-electron atoms is observed both in the numerical solution of a low-dimensional model helium atom and using an extended strong field approximation [1]. It is shown that the harmonics well beyond the usual cut-off are due to the simultaneous recombination of the two electrons, which were emitted during different, previous half-cycles. The new cut-off is explained in terms of classical trajectories. Classical predictions and the time-frequency analysis of the ab initio quantum results are in excellent agreement. The mechanism corresponds to the inverse single photon double ionization process in the presence of a (low frequency) laser field. Its low efficiency can be enhanced with the help of attosecond xuv pulses that control the emission times of the two electrons.

[1] P. Koval, F. Wilken, D. Bauer, C.H. Keitel, Phys. Rev. Lett. (accepted); preprint physics/0609010.

A 9.7 Di 15:45 5M

Orbital imaging with high harmonics: single- vs. multi-electron approach — •Gerald Jordan and Armin Scrinzi — TU Wien, Institut für Photonik

The imaging of molecular orbitals by electron rescattering is revisited from the multi-particle point of view. The interpretation of the experimental data has so far largely relied on the single-active electron approximation, whereby the imaged object is identified with the HOMO of the molecule. In multi-electron systems, correlation tends

to blur the distinction between individual orbitals. We investigate the viability of the single-electron approximation and the significance of the single-electron orbitals (in particular the Dyson orbital).

We use the MCTDHF (multi-configuration time-dependent Hartree-Fock) method to systematically account for correlation effects. Laser ionization of a 3-dimensional model diatomic molecule is simulated with 2 and 4 active electrons. The high harmonic spectra obtained with MCTDHF are compared with two single-electron models based on the Dyson orbital: the strong-field approximation (Lewenstein model), and the solution of the TDSE for an effective 1-electron Hamiltonian with the Dyson orbital built in as the ground state.

The Lewenstein spectra fail to qualitatively reproduce the multi-electron results. Solution of the 1e-TDSE allows to further distinguish between effects related to the SFA and the SAE. The features of the harmonic spectra are associated with the time structure of the rescattering current, which in turn reflects molecular multi-electron ionization dynamics.

A 10: Poster I - Precisions Spectroscopy

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

A 10.1 Di 16:30 Poster B

Low–lying level structure of atomic nobelium and lawrencium: A challenge for ab–initio theory — •S. Fritzsche[1], C. Z. Dong[2], G. Gaigalas[3], and M. Sewtz[4] — [1]Universität Kassel, D–34132 Kassel, Germany — [2]Northwest Normal University, Lanzhou 730070, China — [3]Vilnius Research Institute of Theoretical Physics and Astronomy, — [4]LMU München, D-85748 Garching, Germany

Studies on the transuranium elements have attracted a lot of interest during the last two decades, both by experiment and theory. Beside the challenge of identifying new elements, these investigations aim for a better understanding of the electronic structure in strong fields as well as for insights into the chemical binding in Nature.

In this contribution, we report on relativistic multiconfiguration Dirac–Fock calculations for the low–lying excitation spectrum of atomic nobelium ($Z = 102$) and lawrencium ($Z = 103$). For these elements, there are strong effects of relativity, electron correlations, and bound–state relaxation (for atomic transitions) which must be treated coherently within the same framework [1]. Based on detailed computations for the low–lying resonances, and including the analysis of the absorption rates, two fermium resonances at 25099.8 cm^{-1} and 25111.8 cm^{-1} could be identified recently [2] and have raised the hope that such resonances will be observed also for other heavy elements [3] in the near future using resonance ionization spectroscopy (RIS).

[1] S. Fritzsche, J. Electr. Spec. Rel. Phenon. **114–116**, 1155 (2001).
[2] M. Sewtz et al., Phys. Rev. Lett. **90**, 163002 (2003).
[3] S. Fritzsche, Eur. Phys. J. **D33**, 15 (2005).

A 10.2 Di 16:30 Poster B

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

Modern physics theories allow for a variation of fundamental constants, such as the fine-structure constant. Searches for such a variation on a cosmological timescale are based on the interpretation of quasar absorption spectra. The sensitivity of these tests is limited by the availability of accurate laboratory spectrocopic data of atoms with a complex level structure [1]. A major difficulty in obtaining more precise data is the need for many different laser systems for probing, cooling and initial state preparation.

We report on the progress towards a flexible spectroscopy setup in which we plan to apply direct frequency comb spectroscopy to a cloud of spectroscopy ions trapped in a linear Paul trap that are sympathetically cooled via Mg^+ ions. The appropriately tailored spectrum of the frequency comb is used for initial state preparation and spectroscopy. This allows us to study several different ion species that have resisted precision spectroscopy in the past.

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

A 10.3 Di 16:30 Poster B

Die MAXEBIS als Testionenquelle für HITRAP und das Ladungsbrüten — •Holger Zimmermann[1], Oliver Kester[2], Jochen Pfister[3], Alexey Sokolov[2], Danyal Winters[2] und Hendrik Ernst[2] — [1]LMU München, Schellingstraße 4, 80799 München — [2]GSI Darmstadt, Planckstraße 1, 64291 Darmstadt — [3]Universität Frankfurt, Max-von-Laue-Straße 1, 60438 Frankfurt

Die Frankfurt MAXEBIS wurde an der GSI wieder in Betrieb genommen, um hochgeladenen Ionen für offline-Tests der HITRAP Niederenergiesektion zu liefern. Die MAXEBIS dient dabei vor allem als Testinjektor für die HITRAP-Kühler-Penningfalle. Außerdem dient die MAXEBIS Experimenten zum Ladungsbrüten extern erzeugter, einfach geladener Ionen, was vor allem Experimenten mit hochgeladenen Ionen exotischer Nukliden zu Gute kommt. Durch transversalen und longitudinalen Einschluss von Ionen in einem Elektronenstrahl eignet sich die EBIS zur Erzeugung hoher Ladungszustände. Zu den Tests wurden einfach geladene Barium-Ionen aus einer Oberflächenquelle und Ar-Ionen aus einer Sputterquelle in die MAXEBIS eingeschossen und zu höheren Ladungszuständen ionisiert und wieder extrahiert. Der experimentelle Aufbau und erste Messergebnisse werden vorgestellt.

A 10.4 Di 16:30 Poster B

Weak Interactions in Trapped Single Radium Ions — U. Dammalapati, K. Jungmann, R.G.E. Timmermans, •L. Wansbeek, and L. Willmann — Kernfysisch Versneller Instituut, University of Groningen, 9747 Groningen, Netherlands

The electroweak theory has been confirmed to great precision in high-energy accelerator experiments. One of the outstanding successful predictions of the theory was the existence of the Z^0 boson, that is mixed with the photon and mediates interactions that do not conserve parity. The mixing angle varies with scale due to the polarization of the vacuum by particle-antiparticle pairs. This has only poorly been tested. Interference of Z^0 and photon exchange between the electrons and quarks in an atom or ion results in a tiny breakdown of parity selection rules. A high-precision measurement of the electroweak mixing angle at low momentum scales is possible by monitoring quantum jumps in one single trapped Ra ion with precision laser and radiofrequency techniques combined. The proof of principle was recently given in pilot measurements at Seattle with one single Ba ion. A Ra^+ experiment can now be envisaged with a precision that, together with planned experiments at intermediate energy, can confirm the quantum structure of the electroweak theory over some five orders of magnitude in momentum scale. Such an experiment has been started at the TRIμP facility of the Kernfysisch Versneller Instituut in Groningen, where the needed radioactive Ra isotopes can be produced online. The experiment uses will use a radiofrequency trap and is possible using several all solid state lasers in an elaborate time switching scheme.

A 10.5 Di 16:30 Poster B

Hyperfine structure investigations of the odd configurations of lanthanum atom — •Jerzy Dembczynski, Boguslaw Furmann, Magdalena Elantkowska, and Jaroslaw Ruczkowski — Chair of Quantum Engineering and Metrology, Faculty of Technical Physics, Poznan University of Technology, Nieszawska 13B, 60-965 Poznan, Poland

The hyperfine structure (hfs) of lanthanum atom have been studied with the method of laser induced fluorescence (LIF) in the hollow cathode discharge.

The investigated transitions within three spectral ranges have been excited by stabilized tunable single-mode ring dye lasers (Coherent, model 699-21), operating on Rhodamine 6G and DCM in the spectral range of 570-610 nm and 617-666 nm respectively, and on Stilbene 3 in the spectral range of 410-460 nm.

The hfs magnetic dipole A and electric quadrupole B constants of more than 100 odd levels have been determined (59 of them for the first time).

The hyperfine structure of the odd levels of La I has been analyzed by simultaneous parametrization of one- and two-body interactions for the system of 61 configurations. Magnetic-dipole hyperfine interaction constants A were calculated using the fine structure eigenvectors and

adjusting radial integrals in a least-squares procedure which compare the calculated A constants with the experimental values.

Moreover, the values of energy for the levels up to now unidentified and hyperfine structure A constants were predicted.

A 10.6 Di 16:30 Poster B

Correlation and QED effects on the lifetime, relativistic nuclear recoil and electronic g factor in Ar^{13+} and Ar^{14+} ions — •Z. Harman[1], R. Soria Orts[1], A. Lapierre[1], J. R. Crespo López-Urrutia[1], U. D. Jentschura[1], A. N. Artemyev[1,2], C. H. Keitel[1], V. M. Shabaev[2], H. Tawara[1], I. I. Tupitsyn[1,2], J. Ullrich[1], and A. V. Volotka[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]St. Petersburg State University, Oulianovskaya 1, 198504 St. Petersburg, Russia

The radiative lifetime [1] and isotope shift [2] of the $1s^22s^22p\ ^2P_{3/2} - {}^2P_{1/2}$ M1 transition and the g factor of these levels [3] in B-like argon ions has been determined with high accuracy using the Heidelberg electron beam ion trap. The lifetime corresponding to the above transition has been measured with an accuracy on the order of one per mil. Theoretical calculations predict a lifetime that is significantly lower than this high-precision experimental value. Our mass shift calculations are in excellent agreement with the experimental results and confirm the necessity to include relativistic recoil corrections when evaluating mass isotope shift contributions in medium-Z ions. The g factor of the P states is determined with a 1.5 per mil accuracy by resolving the Zeeman components of the transition. The experimental results are in accordance with our theoretical calculations.

[1] A. Lapierre *et al.*, Phys. Rev. Lett. 95, 183001 (2005).
[2] R. Soria Orts *et al.*, Phys. Rev. Lett. 97, 103002 (2006).
[3] R. Soria Orts *et al.*, to be published

A 10.7 Di 16:30 Poster B

Resonance Laser Spectroscopy on Trapped Highly-Charged Ions using Soft X-rays from FLASH — Sascha Epp, •Jose Crespo Lopez-Urrutia, and Joachim Ullrich — Max-Planck-Institut fuer Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

Resonance laser spectroscopy, the most sensitive tool for atomic structure studies, has been severely limited due to the lack of appropriate light sources beyond the UV and especially the VUV region. With the free electron laser in Hamburg, FLASH, the soft x-ray region is now widely opened to laser spectroscopy and heavy, few-electron systems -i.e. highly charged ions (HCI) - are now accessible by this precision method. The transition between the 2S1/2 (ground) and 2P1/2 (excited) states was investigated for Li-like iron Fe23+ ions by matching soft x-rays from FLASH together with HCI provided in a transportable EBIT. The present statistical accuracy is already superior to the theoretical uncertainties and allows verifying the leading two-photon QED terms.

A 10.8 Di 16:30 Poster B

Precision Lifetime Determination of the Fe XIV $3s^23p\ ^2P^o_{3/2}$ Metastable Level — Guenter Brenner and •Jose Ramon Crespo López-Urrutia — Max-Planck-Insitut für Kernphysik, Heidelberg

The lifetime of the $3s^2\ 3p\ ^2P^o_{3/2}$ first excited energy level of Fe XIV (Al-like) was measured at the Heidelberg electron beam ion trap by monitoring its optical decay to the ground state by a magnetic dipole (M1) forbidden transition at λ=530.29 nm (*green coronal line*), a well known line in stellar spectra. A new trapping scheme has been applied. Possible systematic effects were investigated by studying the dependence of the decay curves on various trapping conditions with high statistical significance. The result of $16.726^{+0.020}_{-0.010}$ ms shows a clear discrepancy of about 4σ to existing theoretical predictions. The inclusion of the electron anomalous magnetic moment (EAMM) within the theoretical calculations increases this disagreement, thus pointing at other possible origins of this discrepancy.

A 10.9 Di 16:30 Poster B

Bestimmung der Absolutfrequenz einer optischen Mg Atomuhr — •Jan Friebe, Karsten Moldenhauer, Matthias Riedmann, Tanja E. Mehlstäubler, Nils Rehbein, André Pape, Alexander Voskrebenzev, Ernst M. Rasel und Wolfgang Ertmer — Institut für Quantenoptik, Leibniz Universität Hannover, Deutschland

Die Frequenz des ^{24}Mg-Interkombinationsübergangs $^1S_0 \rightarrow {}^3P_1$ wurde erstmals atominterferometrisch an einem thermischen Atomstrahl mit einem sub-kHz schmalen Diodenlaser spektroskopiert und mit Hilfe eines Faserfemtosekundenlasers mit einer transportablen Cäsiumatomuhr verglichen. Die Messung wurde in Kooperation mit der PTB durchgeführt und es konnte eine relative Genauigkeit von etwa 10^{-11} erreicht werden. Die Unsicherheit ist im Wesentlichen bestimmt durch einen verbleibenden Dopplereffekt in erster sowie zweiter Ordnung.

An kalten Mg Atomen wurde in der Vergangenheit eine spektroskopische Auflösung von bis zu 290 Hz erreicht, woraus sich eine Kurzzeitstabilität von $8 * 10^{-14}$ in 1 s ableiten lässt [1]. Diese ist durch die Restbewegung der Atome bei einer Temperatur oberhalb des Dopplerlimits von 2 mK limitiert. Da bei ^{24}Mg eine sub-Dopplerkühlung mit herkömmlichen Methoden nicht möglich ist, wurde von uns das vielversprechende Verfahren des Zweiphotonenkühlens [2] untersucht. Wir präsentieren unsere Ergebnisse, bei denen Temperaturen von deutlich unterhalb des Dopplerlimits erreicht wurden.

[1] J. Keupp et al., EPJ D 36, 289-294 (2005)
[2] W.C. Magno et al., Phys. Rev. A 67, 043407 (2003)

A 10.10 Di 16:30 Poster B

A clock laser system for Yb optical frequency standard — •U. Bressel[1], M. Okhapkin[1,2], A.Yu. Nevsky[1], and S. Schiller[1] — [1]Institut für Experimentalphysik, Heinrich-Heine-Universität Düsseldorf — [2]Institute of Laser Physics, Novosibirsk

Ytterbium is a promising candidate for a lattice optical clock [1] with a potential accuracy significantly exceeding that of the best caesium clocks. The 1S0 - 3P0 clock transition at 578 nm is dipole forbidden and has a natural linewidth of about 10 mHz, leading to a transition Q-factor about 10ˆ-16. To interrogate such a narrow transition, a reliable laser source with a sub-Hz linewidth should be developed. In our experiment the radiation at 578 nm is obtained by summing the frequencies of the Nd:YAG laser at 1064 nm and a grating-stabilized diode laser at 1267 nm in the PPLN crystal, placed in the enhancement cavity. We use the ILP-500/30 Nd:YAG laser [2] with intra-cavity frequency doubling. It is locked to a Doppler-free resonance in the molecular iodine. The enhancement cavity is locked to the Nd:YAG laser using the Pound-Drever-Hall technique. The frequency of the diode laser is locked to the cavity, thus making the cavity resonant for both IR radiations and yielding a frequency stability on the level of that of the Nd:YAG/I2 system. With 300 mW at 1064 nm and 20 mW at 1267 nm, the power at 578 nm is about 12 mW. The properties of the 578 nm radiation were characterized and work is in progress to stabilize this radiation to a high-finesse ULE cavity in order to reduce its linewidth.

[1] C.W. Hoyt et al, Phys. Rev. Lett. 95, 083003 (2005)
[2] see http://www.laser.nsc.ru/develop.htm

A 11: Poster I - Collisions with electrons and ions

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

A 11.1 Di 16:30 Poster B

Projectile excitation in relativistic ion–atom collisions: Alignment of excited ionic states — •Stephan Fritzsche[1], Thomas Stöhlker[2], Andrey Surzhykov[3], and Ulrich D. Jentschura[3] — [1]Universität Kassel — [2]Gesellschaft für Schwerionenforschung (GSI), Darmstadt — [3]Max–Planck–Institut für Kernphysik, Heidelberg

Both, the electron capture and Coulomb excitation of heavy projectile ions at storage rings lead to an alignment of the resulting excited ionic states with respect to the beam direction. Such an alignment results subsequently in the emission of characteristic x–ray photons which have an anisotropic angular distribution as well as a nonzero linear polarization. While the (angular and polarization) properties of the characteristic radiation following capture processes have been studied in great detail during the last two decades, less attention has been paid to the Coulomb excitation of the projectiles by the (screened) charge of the target atoms. Only recently the "excitation–and–decay" process have been observed at the GSI facility in Darmstadt for the helium–like uranium U^{90+} ions. The measured alignment of the $1s2p_{3/2}\ J = 1$

excited state was found, however, to be inconsistent with the predictions of a simple one–particle model. In this contribution, therefore, we present a theoretical study of the Coulomb excitation process, based on the Dirac's relativistic equation and the semi–classical approximation, which takes into account the multi–electron aspect of the helium–like ions. By using our theoretical approach, predictions are given for the alignment of the $1s2p_{3/2}$ $J = 1, 2$ states of high–Z projectile ions and are compared with available experimental data.

A 11.2 Di 16:30 Poster B

Investigating correlated few-electron dynamics and QED contributions by means of dielectronic recombination into highly-charged Fe, Kr, Xe, Ba, W, and Hg ions — •Z. Harman[1], V. Mäckel[1], A. J. González Martinez[1], J. R. Crespo López-Urrutia[1], A. N. Artemyev[1,2], U. D. Jentschura[1], C. H. Keitel[1], O. Postavaru[1], H. Tawara[1], I. I. Tupitsyn[1,2], and J. Ullrich[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]St. Petersburg State University, Oulianovskaya 1, 198504 St. Petersburg, Russland

The photorecombination of highly charged He- to B-like ions has been explored in the atomic number range Z=26 to 80 with the Heidelberg electron beam ion trap [1,2]. The energies of state-selected dielectronic recombination (DR) resonances were determined over the KLL region. At the present level of experimental accuracy, it becomes possible to make a detailed comparison to various theoretical approaches and methods, all of which include relativistic and quantum electrodynamic (QED) effects. Theoretical resonance energies for KLL DR are calculated by various means [3]. The comparison of theoretical values with the experimental energies shows a good overall agreement. Few discrepancies are found in specific recombination resonances for initially Li- and Be-like heavy ions.

[1] A. J. González Martínez *et al.*, Phys. Rev. A 73, 052710 (2006).
[2] V. Mäckel *et al.*, to be published
[3] Z. Harman *et al.*, Phys. Rev. A 73, 052711 (2006).

A 11.3 Di 16:30 Poster B

3D-Bilder der Elektronstoßionisation von Atomen — •Alexander Dorn, Martin Dürr, Xueguang Ren, Vladimir Borovik, Arne Senftleben und Joachim Ullrich — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Mit dem Reaktionsmikroskop (RM), einem kombinierten Elektronen- und Rückstoßionen-Impulsspektrometer lässt sich die Dynamik von atomaren Stoß- und Fragmentationsprozessen im Detail untersuchen. Mit einem speziell für niederenergetische Elektronenstoßprozesse konzipierten RM können nun kinematisch vollständige Untersuchungen über einen großen Projektilenergiebereich bis hinunter zur Ionisationsschwelle durchgeführt werden. In diesem Beitrag werden Ergebnisse zur Einfach- und Doppelionisation ((e,2e) und (e,3e) Prozesse) von Helium, Argon und anderen Targetatomen vorgestellt. Diese umfassen den vollen Raumwinkel für die ionisierten Elektronen und einen großen Bereich von Projektilstreuwinkeln. Es lassen sich erstmals Wirkungsquerschnitte für alle Emissionsrichtungen als 3D-Bilder darstellen und entsprechende theoretische Rechnungen umfassend testen.

A 11.4 Di 16:30 Poster B

Cold electron beams for high-resolution storage-ring electron collision spectroscopy. — •Michael Lestinsky, Jens Hoffmann, Dmitry Orlov, and Andreas Wolf — Max-Planck-Institut für Kernphysik, D-69117 Heidelberg

High-resolution electron collision spectroscopy uses a merged beams arrangement with a magnetically guided electron beam in heavy ion storage rings to observe resonant processes such as dielectronic recombination of atomic and dissociative recombination of molecular ions. At low energies, energy resolutions can reach down to 0.5 meV with a photocathode source. At higher energies the achievable resolution is limited by the energy spread parallel to the overall motion of the beam, usually expressed by the longitudinal temperature $kT_{\|}$.

The influence of realistic acceleration arrangements, employing magnetic transverse expansion and a long section for slow (adiabatic) acceleration (0.45 m), has been systematically investigated at the cold electron target of the TSR Heidelberg. At a beam energy of 4 keV, lower limits of $kT_{\|}$ of 29 μeV and 11 μeV were realized at the two current extremes of 10 mA and 0.05 mA, respectively. For fast acceleration, the temperatures were found to be higher by up to 25%. A guiding field of 0.06 T was used to keep the rise of $kT_{\|}$ by electron scattering low, so that expected effects of the acceleration structure became visible. The results help to guide the layout of future high-resolution beam devices, such as at the NESR at GSI/FAIR or at the CSR Heidelberg.

A 11.5 Di 16:30 Poster B

Streudifferenzieller Wirkungsquerschnitt für einen Elektronentransfer in Stößen von H^+ und Helium — •Hong-Keun Kim[1], Markus Schöffler[1], Jasmin Titze[1], Lothar Schmidt[1], Ottmar Jagutzki[1], Reinhard Dörner[1], Horst Schmidt-Böcking[1] und Ivan Mancev[2] — [1]Institut für Kernphysik, Johann Wolfgang Goethe Universität, Frankfurt, Deutschland — [2]Department of Physics, University of Nis

Bei H^+-Helium Stößen wurde der streuwinkel differenzielle Wirkungsquerschnitt des Einelektronentransfers (single capture, SC) bestimmt. Bei Projektilenergien zwischen 60 und 1200 keV/u wurden sowohl der Einfluss großer bzw. sehr kleiner Störungen abgedeckt. Zur experimentellen Untersuchung kam die Technologie der Rückstoßionenimpulsspektroskopie (COLTRIMS) zum Einsatz. Bei den höchsten untersuchten Einschussenergien gab es Evidenzen für Prozesse höherer Ordnung wie den Elektron-Kern-Thomas-Prozess. Die experimentell erfassten Daten stehen in guter Übereinstimmung mit neuen theoretischen Ergebnissen der four-body one-channel distorted wave Modelle (CDW-BFS,CDW-BIS und BDW).

A 11.6 Di 16:30 Poster B

Stossinduzierte Ionisation und Fragmentation von Acetylen — Bärbel Siegmann[1] und •Udo Werner[2] — [1]Institut für Physik, Universität Dortmund, 44221 Dortmund — [2]Fakultät für Physik, Universität Bielefeld, 33615 Bielefeld

Die Mehrfachionisation und Fragmentation von C_2H_2 wurde in Stössen mit 100–200 keV H^+, He^+ und O^+ Ionen untersucht. Die im Stoss erzeugten Elektronen und Ionen werden durch ein homogenes elektrisches Feld separiert und mit einem orts- und zeitauflösenden Multi-Hit-Detektor nachgewiesen, der die koinzidente Messung der Impulsvektoren korrelierter Fragmentionen erlaubt. Hierdurch kann die Kinematik einzelner Fragmentationskanäle, wie z.B. $C_2H_2 \rightarrow CH^+ + CH^+$ oder $C_2H_2 \rightarrow H^+ + C^+ + CH^+$, vollständig analysiert werden, wodurch neben der Bestimmung von relativen Wirkungsquerschnitten auch die Analyse von Winkelkorrelationen und der kinetischen Energien der Fragmentionen möglich wird. Die gemessenen Verteilungen liefern wertvolle Hinweise auf die Fragmentationsdynamik: so findet man beispielsweise für den Kanal $C_2H_2 \rightarrow H^+ + C_2^+ + H^+$, dass neben simultanen Fragmentationsprozessen auch schrittweise Prozesse eine Rolle spielen.

A 11.7 Di 16:30 Poster B

Winkeldifferentielle Wirkungsquerschnitte für Edelgasmehrfachionisation durch Protonen unter Berücksichtigung von Auger-ähnlichen Zerfallsprozessen — Tobias Spranger, Myroslav Zapukhlyak und •Tom Kirchner — Institut für Theoretische Physik, TU Clausthal

Wir betrachten einfache und mehrfache Ionisation von Neon und Argon durch energiereiche Protonen im Modell unabhängiger Teilchen. Bei Projektilenergien über etwa einem MeV dominieren Auger-ähnliche Zerfallsprozesse die Mehrfachionisation. Diese können durch unser kürzlich eingeführtes statistisches Modell adäquat beschrieben werden [1]. Wir zeigen, wie mit Hilfe einiger Streumodelle (Rutherford und realistischere Modelle), winkeldifferentielle Wirkungsquerschnitte gewonnen werden können. Mit diesen Ergebnissen kann eine jahrzentelange Diskrepanz zwischen verschiedenen Experimenten ausgeräumt werden.

[1] Tobias Spranger and Tom Kirchner. J. Phys. B, 37(20): 4159-4165, 2004.

A 11.8 Di 16:30 Poster B

Cross sections for $\bar{p}$ - He collisions — •Armin Lühr and Alejandro Saenz — Humboldt-Universität zu Berlin, Institut für Physik, Moderne Optik, Hausvogteiplatz 5-7, D-10117 Berlin

Although the interaction between matter and antimatter has been a fascinating topic for many years, a lot of open questions still remain. In the case of $\bar{p}$ - He scattering there is a clear discrepancy between experimental and theoretical results at low impact energies (< 50 keV). In the near future improved conditions for the production of slow antiproton beams at the new antiproton facility at GSI Darmstadt are expected to provide the basis for new and more reliable experimental data. This gives also new impetus to theoretical investigations which in turn should be useful for the design of this new experimental facility.

We present theoretical results for cross sections of $\bar{p}$ - He collisions with energies > 0.1 keV. The calculations are based on a time-dependent close coupling method. Similar to a previous work [1] we have chosen a configuration-interaction (CI) based one-center approach. However, we expand the one-electron wave function in terms of B-spline functions as has been done in [2] for an effective one-electron treatment. The trajectory of the antiproton is considered to be classical. The consequences of this approximation will be addressed in future work.

[1] A. Igarashi *et al.*, Phys. Rev. **A** 64, 042717 (2001)
[2] S. Sahoo *et al.*, Nucl. Inst. Phys. Res. **B** 233, 318 (2005)

A 11.9 Di 16:30 Poster B

Erste Experimente mit einem In-Ring Reaktionsmikroskop im Schwerionen-Speicherring ESR der GSI — •Marco Schäfer[1], Daniel Fischer[3], Siegbert Hagmann[2], Thomas Ferger[1], Kai-Uwe Kühnel[1], Muaffaq Nofal[2], Christophor Kozhuharov[2], Christina Dimopoulou[2], Markus Steck[2], Thomas Stöhlker[2], Carsten Brandau[2], Harald Bräuning[2], Hermann Rothard[4], Gaetano Lanzano[5], Enrico de Filippo[5], Robert Moshammer[1] und Joachim Ullrich[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Gesellschaft für Schwerionenforschung mbH, Darmstadt, Germany — [3]Physics Department of Stockholm University, Stockholm, Sweden — [4]CIRIL, Caen, France — [5]INFN, Catania, Italy

Mit einem eigens für den Experimentier-Speicherring ESR der GSI konzipierten Reaktionsmikroskop wurden erste Experimente zur Vielfachionisation von Neon und Argon Atomen in Stößen mit hochenergetischen (230 MeV/u) U^{90+} Ionen durchgeführt. Hierbei könnten bis zur 10-fachen Ionisation von Ar die Impulsverteilungen der emittierten Elektronen vermessen werden. Des Weiteren war es möglich umgeladene Projektile in Koinzidenz mit einem ionisierten Targetatom nachzuweisen und damit den Elektroneneinfang in Stößen von im Ring abgebremsten U^{92+} (13MeV/u) mit Ne zu untersuchen. Ein Überblick über die durchgeführten Experiment und erste Ergebnisse werden vorgestellt.

A 11.10 Di 16:30 Poster B

Kinematically complete study on transfer-excitation in intermediate-energy p-He collisions — Myroslav Zapukhlyak[1], •Tom Kirchner[1], Ahmad Hasan[2,3], Brian Tooke[2], and Michael Schulz[2] — [1]Institut für Theoretische Physik, TU Clausthal, Leibnizstraße 10, 38678 Clausthal-Zellerfeld — [2]Physics Department and Laboratory for Atomic, Molecular, and Optical Research, University of Missouri-Rolla, Rolla, Missouri 65409, USA — [3]Department of Physics, UAE University, P.O. Box 17551, Alain, Abu Dhabi, United Arab Emirates

Very recently, we have reported the first measured differential cross sections for transfer excitation in p-He collisions at 25, 50, and 75 keV impact energy. A comparison with double excitation data and with nonperturbative time-dependent calculations indicated that dynamic couplings between the motion of the heavy particles and the electronic transitions and/or electron-electron correlation effects must play a role in these processes [1].

Refined calculations on the basis of the eikonal approximation for the extraction of differential cross sections give a more definite answer: they show that it is the quantal nature of the heavy particle-electron coupling that produces experimentally observed structures in double ratios of transfer-excitation to single capture and double to single excitation cross sections.

[1] A. Hasan et al, Phys. Rev. A 74, 032703 (2006)

A 11.11 Di 16:30 Poster B

Projectile Continuum Processes in Relativistic Ion-atom Collisions — •Muaffaq Nofal[1,3], Siegbert Hagmann[2,3], Thomas Stöhlker[3], Christophor Kozhuharov[3], Xincheng Wang[4], Alexander Gumberidze[3], Uwe Spillmann[3], Regina Reuschl[3], Sebastian Hess[3], Sergej Trotsenko[3], Darek Banas[3], Dieter Liesen[3], Doris Jakubassa-Amundsen[5], Joachim Ullrich[1], Robert Moshammer[1], Reinhard Dörner[2], Hermann Rothard[6], and Markus Steck[3] — [1]Max Planck Institut f. Kernphysik, Heidelberg, Deutschland — [2]Inst. f. Kernphysik, Univ. Frankfurt, Deutschland — [3]GSI, Darmstadt, Deutschland — [4]Fudan University, Shanghai, China — [5]Mathem. Institut, LMU, München — [6]Ciril, Ganil, Caen, Frankreich

We have measured at the storage ESR for 90AMeV U(88+) + N2 differential cross sections for forward electron emission. Electrons emitted into a narrow forward cone around the projectile direction are momentum analyzed with a magnetic forward electron spectrometer of the dipole-quadrupole-dipole type equipped with a 2D position sensitive electron detector. Electrons are measured in coincidence with charge exchanged projectiles U(89+) for electron loss (ELC) and U(87+) for simultaneous electron capture to bound and continuum states (ECC2). The ELC cusp is very narrow and symmetric; it is attributed to projectile 2s ionization. In contrast the ECC2 cusp is visibly skewed to the low momentum side. Comparisons with theoretical calculations are in progress.

A 12: Poster I - Interaction with external fields

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

A 12.1 Di 16:30 Poster B

Berry Phases in a Hydrogen Atomic Beam Spin Echo Setup — Maarten DeKieviet, Sacher Khoudari, •Christian Roux, and Thorsten Schult — Physikalisches Institut, Uni Heidelberg

Berry Phases (BPs) in quantum mechanics, which are purely geometric in origin, have been measured using a wide variety of systems and techniques. In the last few years BPs have received renewed interest due to the possibility of using them as quantum computing gates. This is motivated by the belief that these phases should be naturally fault tolerant in the presence of external noise. In addition, latest theoretical results predict that BPs can be used to measure parity-violating effects in a hydrogen atomic beam spin echo setup. Measurements in light systems like the hydrogen atom are of great interest because theoretical calculations can be done with high accuracy and therefore may help to clarify the spin-puzzle of the nucleon.

The atomic beam spin echo technique gives an opportunity to separate the geometric from the quantum mechanical dynamic phase in appropriate magnetic fields and therefore allows a detailed study of the behavior of the BP. At present we are building an experimental setup capable of measuring BPs between 0 and 2π and, in analogy to the conventional dynamical Spin-Echo, a first "Berry-Echo".

A 12.2 Di 16:30 Poster B

Berry phase in atomic scattering — •Polina V. Mironova, Maxim A. Efremov, and Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm, Ulm, Germany

The Berry phase is determined only by the topology of parameter space and therefore cannot be disturbed by noise. It could be of use for the construction of robust quantum gates. We consider the scattering of a two-level atom by a resonant standing light wave. In our scheme an atom interacts with (i) the standing wave, (ii) the pi-pulse, (iii) the second standing wave which is identical to the first one, and (iv) the second pi-pulse. In the adiabatic approximation of the atomic center-of-mass motion, an adiabatically slow switch-on and -off of the atom-standing wave interaction we shown that we can controll the atomic state population at each moment of the interaction. We suggest a four-step scheme of atom scattering will lead to cancelling of the dynamical phase and the scattering picture will be determined only by the position-dependent geometrical phase.

A 12.3 Di 16:30 Poster B

Negative Energy Resonances of Bosons in a Magnetic Quadrupole Trap — •Shahpoor Saeidian[1] and Peter Schmelcher[1,2] — [1]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg, Germany — [2]Theoretische Chemie, Institut für Physikalische Chemie, Universität Heidelberg, INF 229, 69120 Heidelberg, Germany

We investigate resonances of spin 1 bosons in a three-dimensional magnetic quadrupole field. Complementary to the well-known positive energy resonances it is shown that there exist short-lived, i.e. broad,

negative energy resonances. The latter originate from a fundamental symmetry of the corresponding Hamiltonian. They are characterized by an atomic spin that is aligned antiparallel to the local magnetic field direction. In contrast to the positive energy resonances the lifetimes of the negative energy resonances decreases with increasing total magnetic quantum number. We derive a mapping of the two branches of the spectrum.

A 12.4 Di 16:30 Poster B

Photoelectron emission from two Rabi-coupled levels — •Mircea Girju and Dieter Bauer — Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg

Photoelectron spectra for the strong field ionization from the Rabi-coupled 1s and 2p states in hydrogen are calculated. Comparisons between results obtained with an extended strong field approximation and the solution of the time dependent Schrödinger equation are presented for different numbers of cycles of the ionizing laser pulse, Rabi-field strengths, and for vanishing or partial overlap between the ionizing pulse and the Rabi field. As in some cases the ionization due to the latter may be kept low, agreement between the two methods is shown. For some ionizing- and Rabi-field strengths without overlap the 2p contribution to the ionization rate can be also observed.

A 12.5 Di 16:30 Poster B

Switching in endohedrals through an external static field — •Paula Rivière[1], Jan-Michael Rost[1], and Mohammed Madjet[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Dresden — [2]Institut für Chemie, Freie Universität Berlin

Endohedral fullerenes $M@C_{60}$, where an atom M is trapped inside a hollow fullerene cage C_{60}, have arisen significant interest in the last years, due to their unique properties. For example, the C_{60} cage acts as a Faraday cage protecting the quantum state of the inner atom, which can be useful for future applications. The fullerene also acts as a resonance cage, since collective effects lead to resonances in the photoionization cross sections of encapsulated atoms. The equilibrium position, r_e, of different inner atoms inside the cage has also been studied. However, a future use of endohedrals as stable quantum systems requires a control of the quantum state of the inner atom.

Maybe the simplest way of changing the state of the inner atom is changing its position within the cage. In fact, during illumination of an endohedral with (weak) laser light, the polarization of the electronic cage changes. In response, the inner atom alters its position. We have studied this process within the linear response theory, for $M = Li^+$, Na^+, and K^+. The fullerene is described within DFT, using the jellium model. The effect of polarization on r_e is obtained from the minimum of the potential, which has a repulsion-dispersion contribution and a polarization contribution. A switching process in r_e can be observed as a function of the energy of the external field, with special structures centered at the position of the surface and volume resonances of C_{60}.

A 13: Poster I - Ultra-cold plasmas and Rydberg systems

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

A 13.1 Di 16:30 Poster B

Vielteilchen-Effekte in ultrakalten Rydberggasen — •Cenap Ates und Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden

Die starke Wechselwirkung zwischen Rydbergatomen eröffnet die Möglichkeit ein nahezu ideales Gas aus Grundzustandsatomen in ein stark wechselwirkendes System durch Anregung von Atomen in Rydbergzustände zu überführen. Ist zusätzlich die Temperatur des Gases so gering, dass thermische Stöße während der Beobachtungsdauer vernachlässigt werden können, weist die Dynamik dieser Systeme viele Parallelen zur Physik von Excitonen in Festkörpern auf. Basierend auf dieser Analogie werden in diesem Beitrag einige Aspekte der stark korrelierten Dynamik in ultrakalten Rydberggasen diskutiert.

A 13.2 Di 16:30 Poster B

Controlling ultracold Rydberg atoms in the quantum regime — •Bernd Hezel[1], Igor Lesanovsky[2], and Peter Schmelcher[1,3] — [1]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg, Germany — [2]Institut für Theoretische Physik, Universität Innsbruck, Technikerstr. 25, 6020 Innsbruck, Austria — [3]Theoretische Chemie, Institut für Physikalische Chemie, Universität Heidelberg, INF 229, 69120 Heidelberg, Germany

We discuss the quantum dynamics of ultracold Rydberg atoms in a magnetic Ioffe Pritchard trap. The derived Hamiltonian displays how tight traps introduce finite size effects into the coupling of the atom to the magnetic field. We solve the Schrödinger equation of the system within a given n-manifold. For sufficiently large Ioffe-fields the system of coupled Schrödinger equations decomposes into $2n^2$ decoupled equations that govern the center of mass motion. The analysis of the combined center of mass and electronic quantum states reveals that the spatial extension of the electronic Rydberg state can exceed the extension of the ultracold center of mass motion. Investigating the situation of tight center of mass confinement outlines the procedure to generate a low-dimensional ultracold Rydberg gas.

A 13.3 Di 16:30 Poster B

Signatures of ultra-long-range Rydberg Molecules in photoassociation — •Ivan Liu and Jan-Michael Rost — Max-Planck Institute for the Physics of Complex Systems, Nöthnitzer Str. 38, D-01187, Dresden

The formation of ultra-long-range molecules was predicted in 2000 [1], involving a highly-excited (Rydberg) atom and a nearby ground-state atom. The adiabatic curves exhibit global minima at approximately $1.5n^2$, where n is the principle quantum number of the Rydberg atom, suggesting the enormous size of this dimer. The polyatomic Rydberg molecules have also been predicted [2]. Recently, some features of this molecular curve have been observed in the old experimental data [3]. Yet the direct evidence of the formed bound dimer is still lacking, largely due to the need to understand the photoassociative process.

Using the simplest excitation scheme in an ultracold Rb gas with realistic parameters, we reveal the signatures of such Rydberg molecules. They enter through the characteristic line shape of the free-bound molecular resonance, which was calculated numerically, thereby confirms the experimental realizability. Moreover, the important informations such as the rate of the formation and the life time of the molecules are obtained. They are both of fundamental interest and useful for the delicate quantum engineering of ultra-long-range molecules.

[1]Greene *et al* PRL 85, 2458 (2000)
[2]Liu and Rost EPJD 40, 65 (2006)
[3]Greene *et al* PRL 97, 233002 (2006)

A 13.4 Di 16:30 Poster B

Collective modes in Ultracold Plasmas — •Andrey Lyubonko and Jan-Michael Rost — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden

Ultracold plasmas (UCP) are relatively new physical systems which have been intensively studied since 1999 [1]. The possibility of creation of finely controlled strongly coupled Coulomb systems on the basis of UCP is one of the motivations. A new feature of UCP was observed recently namely the existence of electronic collective modes (Tonks-Dattner resonances) [2]. Beyond fundamental interest such modes may provide an accurate method to determine the time-dependent electron temperature of UCP.

The first two moments of the collisionless Boltzmann equation assuming a scalar pressure are used to describe the collective modes in UCP. The similar hydrodynamical model was successfully applied to Tonks-Dattner resonances in hot plasma in the past [3] . We will present the results of a similar approach for the resonances in UCP incorporating the additional complication of the finite size of an UCP.

[1] T. C. Killian, S. Kulin, S. D. Bergeson, L. A. Orozco, C. Orzel, and S. L. Rolston, Phys. Rev. Lett., 83(23):4776 (1999)
[2] R. S. Fletcher, X. L. Zhang, and S. L. Rolston, Phys. Rev. Lett., 96:105003 (2006)
[3] J.V. Parker, J.C. Nickel, and R. W. Gould, Phys. Fluids 7, 1489 (1964).
[4] T.C. Killian, T. Pohl, T. Pattard and J M Rost, Physics Reports submitted, (2006), http://arxiv.org/pdf/physics/0612097

A 14: Poster I - Ultra-cold atoms, ions and BEC

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

A 14.1 Di 16:30 Poster B

Transportable Rubidium magneto-optical trap as a high precision target for highly charged ions — •Simone Götz, Magnus Albert, Judith Eng, Terry Mullins, Wenzel Salzmann, Roland Wester, and Matthias Weidemüller — Physikalisches Institut, Universität Freiburg, Hermann Herder Str.3, D-79104 Freiburg i. Br.

A transportable magneto-optical trap for rubidium atoms is presented which serves as a high precision target with high densities for ion beams and photons. In scattering experiments with highly charged ions the low temperature of the target atoms ($< 100\mu K$), corresponding to very low momentum spreads of the rubidium atoms ($\delta p < 0.01$), ensures a high resolution measurement of the recoil ion momentum components using Recoil-Ion-Momentum Spectroscopy (RIMS) [1]. The setup will be tested with multiphoton ionization experiments in strong ultrashort laser pulses. Adding photon and x-ray detectors and performing time-coincidence measurements, the process of double and triple electron transfer from the target atoms to the projectile atoms can be investigated in detail. Resonance phenomena are expected to be observed.

[1]S. Vajda *et al.* Chem.Phys. 267, 231-239,(2001)

A 14.2 Di 16:30 Poster B

Rydberg atom in a Bose-Einstein condensate — •Stephan Middelkamp[1], Peter Schmelcher[1,2], and Igor Lesanovsky[3] — [1]Theoretische Chemie, Institut für Physikalische Chemie, Universität Heidelberg, INF 229, D-69120 Heidelberg, Germany — [2]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, D-69120 Heidelberg, Germany — [3]Institute of Electronic Structure and Laser, Foundation for Research and Technology Hellas, P.O. Box 1527, GR-71110 Heraklion, Greece

We present a new method of determening characteristic paramenters of a Bose-Einstein condensate via spectroscopy of the electronic excitation levels of one of the condensate's atoms. We calculated the energy levels of a Rydberg atom embedded in a Bose-Einstein condensate for different trapping potentials. These energy levels depend on characteristic parameters of the Bose-Einstein condensate. Therefore one can gain information about the Bose-Einstein condensate by determening the electronic excitation levels of the Rydberg atom via spectroscopy.

A 14.3 Di 16:30 Poster B

Superradiant Rayleigh scattering in a high finese ring cavity — •Gordon Krenz, Sebastian Slama, Simone Bux, Claus Zimmermann, and Philippe Courteille — Physikalische Institut, Eberhard-Karls-Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

We study the collective interaction of light with ultracold rubidium atoms. We are interested in the sudden build-up of a reverse light field in a laser-driven high-finesse ring cavity filled with ultracold thermal or Bose-Einstein-condensed atoms. While superradiant Rayleigh scattering from atomic clouds is normally only observed at very low temperature (1 μK), the presence of a ring cavity enhances cooperativity and allows for superradiance with thermal clouds as hot as several 10 μK. A characterization of the superradiance at various temperature and cooperativity parameters allows us to link it to the collective atomic recoil laser (CARL).

A 14.4 Di 16:30 Poster B

Thomas-Fermi approximation for a BEC in an optical dipole trap — •Walter Strunz and Lena Simon — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Motivated by an experiment in the Helm group at the University of Freiburg, we study a Bose-Einstein condensate in an optical dipole trap. On the basis of the Thomas-Fermi theory we obtain analytical expressions valid beyond the usual harmonic approximation. We determine relevant condensate properties and compare with the exact solution of the Gross-Pitaevskii equation. Finally we focus on the release dynamics as studied in the experiment.

A 14.5 Di 16:30 Poster B

Thermal dephasing of a Bose- Einstein Condensate in a double well potential — Walter Strunz and •Sigmund Heller — Physikalisches Institut, Universität Freiburg, Hermann- Herder- Straße 3 79104 Freiburg i. Br.

Our primary goal is a thorough understanding of the phase of a Bose-Einstein- condensate in a double well potential. Within a two mode model [1,2] we calculate the phase classically and quantum mechanically and compare it with experimental results of the Oberthaler group (Heidelberg University)[3]. The ground state and first excited state are obtained by a 3D imaginary time propagation.

In order to consider the influence of additional states we introduce a new stochastic Gross- Pitaevskii equation for finite temperature that provides the canonical ensemble on average. We discuss properties of this Langevin equation.

[1] L. Pitaevskii and S. Stringari. Phys. Rev. Lett. 87.180402 (2001).
[2] D. Ananikan and T. Bergemann. Phys. Rev. A 73.013604 (2006).
[3] R. Gati, B. Hemmerling, J. Foelling, M. Albiez and M. K. Oberthaler. Phys. Rev. Lett. 96.130404 (2006).

A 14.6 Di 16:30 Poster B

EIT-based cooling of neutral atoms — •Maryam Roghani and Hanspeter Helm — Department of molecular and optical physics, Stefan-Meier-Str. 19,D-79104 Freiburg,Germany

The concept of EIT has recently been discussed as a means of cooling neutral trapped atoms [1]. We attempt to evaluate this scheme under using realistic parameters as they are present in an optical dipole trap for Rb atoms and discuss the potential sensitivity of the cooling scheme using a realistic multi-level atom. Specifically we wish to address likely limitations in the applicability of the EIT scheme for neutral atom traps. Such limitations arise from a variety of reasons. Among these are: a) the low vibrational frequencies of atoms in dipole traps, b) the effect of anharmonicities (these appear naturally from the intensity profile of the laser beam but also due to the gravitational potential and the mean field of interaction), c) the substantial difference in vibrational frequencies for ground and excited state atoms (unless the trap is operated at a magic wavelength for which the AC-Stark shifts of ground and excited state are identical), d) the sensitivity of the scheme to residual magnetic fields and to fluctuations of the laser fields, e) the necessity of an artificially introduced spatial dependence of the transistion dipole moment in order to enforce off-diagonal vibrational transitions. [1]. F. Schmidt - Kaler, J. Eschner, G. Morigi, C. F. Roos, D. Leibfried, A. Mundt, R. Blatt, Laser cooling with electromagnetically induced transparency: application to trapped samples of ions or neutral atoms. Appl. Phys. B 73, 807 (2001).

A 14.7 Di 16:30 Poster B

Study of the Born-Oppenheimer Approximation for Mass-scaling of Cold Collision Properties — •Stephan Falke, Eberhard Tiemann, and Christian Lisdat — Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover

Ultracold collisions of atoms are often described by the s-wave scattering length. Also, positions and widths of Feshbach resonances characterize these collisions. Full information about the scattering wavefunctions is given by interaction potential curves, which can be determined by molecular spectroscopy. Adding neutrons to one of the nuclei does not alter the potential curve (Born-Oppenheimer approximation, BOA). It is possible to derive eigenvalues, Feshbach resonances, and the scattering length for different isotope combinations from a single potential simply by changing the reduced mass if the BOA is fulfilled. We study the validity of the BOA for asymptotic levels of the potential curve describing the A $^1\Sigma_u^+$ state [1] of K_2 (correlated to the $4s_{1/2}+4p_{1/2}$ asymptote) by comparing spectra of the two isotopomers $^{39}K_2$ and $^{39}K\,^{41}K$ obtained by high resolution laser spectroscopy in a molecular beam.

[1] J. Chem. Phys. **125**, 224303 (2006).

A 14.8 Di 16:30 Poster B

An electrodynamic trap for neutral atoms — •Sophie Schlunk[1,2], Adela Marian[1], Allard Mosk[3], Peter Geng[1], Wieland Schöllkopf[1], and Gerard Meijer[1] — [1]Fritz-Haber-Institut, Berlin, Germany — [2]FOM-Institute for Plasmaphysics Rijnhuizen, Nieuwegein, The Netherlands — [3]University of Twente, Enschede, The Netherlands

We are implementing an AC electric trap for atoms, which has been proposed by Peik [Eur. Phys. J. D 6, 179 (1999)]. The predicted potential-well depths for Rb atoms are on the order of 15 μK. It has

been shown that polar molecules can be trapped in such an AC electric trap [PRA 74, 063403 (2006)]. Electrodynamic trapping of Sr atoms has also been demonstrated on an atom chip [PRL 96, 123001 (2006)].

The basic idea behind our AC trap is to create an electric field configuration that has a saddle point of constant field strength at the center of the trap and slopes of opposite signs in the axial and radial directions. Switching between the two electric field configurations gives confinement in 3D, by generating an alternately focusing and defocusing force in each direction.

In the experiment, the Rb atoms are cooled in a standard MOT loaded from a Zeeman slower. After loading the atoms in a magnetic trap, a density on the order of 10^{11} atoms/cm^3 and a temperature of about 100 μK are measured. Next, the cold Rb cloud is transferred to a second vacuum chamber by physically moving the magnetic trap. This second vacuum chamber houses the AC trap.

At the meeting we will report on our latest results.

A 14.9 Di 16:30 Poster B

All-Optical Realization of a Bose-Einstein Condensation in a Dipole Trap — •Christoph Käfer, Riad Bourouis, Jürgen Eurisch, Maryam Roghani, and Hanspeter Helm — Department of Molecular and Optical Physics, Stefan-Meier-Straße 19, 79104 Freiburg, Germany

We trap up to $3 \cdot 10^8$ ^{87}Rb atoms in a conventional 3D-MOT, which is fed from a high pressure 2D-MOT source. The 3D-MOT overlaps spatially with the tight focus of a 27 Watt CO_2 laser (initial trap frequencies: ν_r= 2400 Hz, ν_z= 160 Hz). The loading of the dipole trap is accomplished in a 60 ms molasses phase with strongly detuned trap laser beams. After transferring about 1 % of the atoms into the dipole trap, we start a phase sequence, where forced evaporation leads to a cold sample of atoms within 5-9 s. Optimizing the last step, a Bose-Einstein Condensate of typically 30000 atoms at densities exceeding $2 \cdot 10^{13}$ atoms/cm^3 is formed. We discuss the technical setup and give a detailed characterization of the trapped gas throughout the experimental cycle as well as effects of inhomogeneous magnetic fields.

A 14.10 Di 16:30 Poster B

Eine neue Apparatur für Fermionen in einer optischen Mikrofalle — •Timo Ottenstein[1], Friedhelm Serwane[1] und Selim Jochim[1,2] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Fakultät für Physik und Astronomie, Universität Heidelberg

Für ein neuartiges Experiment mit wenigen fermionischen Atomen in einer optischen Mikrofalle bauen wir eine neue Apparatur auf. Ausgangspunkt für die Experimente soll ein Bose-Einstein-Kondensat von $^6Li_2$-Molekülen sein, das auf etablierte Weise in einer optischen Dipolfalle erzeugt wird. Ein entscheidender Vorteil eines solchen Kondensats ist die Einstellbarkeit der Wechselwirkung zwischen den ^{6}Li-Atomen, die so weit reicht, dass das Kondensat in ein superfluides Gas von wechselwirkenden Fermionen konvertiert werden kann (BCS-Gas). Ein solches Kondensat wird in eine stark fokussierte optische Mikrofalle transferiert, die eine Größe von wenigen Mikrometern hat. Das Potential dieser Mikrofalle lässt sich durch Absenken der Intensität so genau kontrollieren, dass nur noch wenige Quantenzustände in der Falle lokalisiert sind. Das lässt sich ausnutzen, um gezielt alle Atome aus der Falle auszuschütten bis auf die Teilchen, die sich in den wenigen noch gebundenen Zuständen der Falle befinden. Über den Fortschritt des experimentellen Aufbaus wird berichtet

A 15: Atomic Systems in External Fields I

Zeit: Mittwoch 11:30–13:00 Raum: 5M

A 15.1 Mi 11:30 5M

Erzeugung höherer Harmonischer mittels maßgeschneiderter Laserpulse — •Michael Klaiber[1,2], Karen Z. Hatsagortsyan[1] und Christoph H. Keitel[1] — [1]Max-Planck Institut für Kernphysik, Heidelberg — [2]Physikalisches Institut der Albert-Ludwigs-Universität Freiburg

Die Wechselwirkung von maßgeschneiderten Laserpulsen mit atomaren Systemen im relativistischen Parameterbereich wird theoretisch untersucht. Der durch die Lorentzkraft des Lasermagnetfeldes verursachte Drift des ionisierten Elektrons wird durch Optimierung der Pulsform stark verringert und die Rekombinationswahrscheinlichkeit massiv erhöht. Basierend auf der Klein-Gordon-Gleichung wird die Emissionsrate höherer Harmonischer berechnet und eine Erhöhung der Rate um mehrere Größenordnungen im Vergleich zu sinusförmigen Lasern vorhergesagt. Das zum Atom zurückkehrende Elektron kann bei realistischen Laserparametern Energien im MeV-Bereich besitzen und damit harte Röntgenstrahlung oder Kernreaktionen im Atom auslösen.[1]

[1] M. Klaiber, K. Z. Hatsagortsyan, C. H. Keitel, Phys. Rev. A 74, 051803(R) (2006).

A 15.2 Mi 11:45 5M

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

We present calculations of the cross section for laser-assisted bremsstrahlung, the first numerical evaluation of a second-order quantum electrodynamic process with the Dirac-Volkov propagator in a strong laser field [1]. In this process an electron in a strong laser field collides with a nucleus and emits a non-laser mode photon. The electron-laser interaction can be treated exactly by using the analytical solutions and propagators of the Dirac equation in an external plane-wave field, while the interaction with the nucleus and the emitted photon is taken into account perturbatively. Numerical results are presented for laser intensities of order 10^{21} W/cm^2, for both circular and linear polarization of the laser. In particular we show that this process is resonant, due to the periodic nature of the laser, and we mention how to deal with these resonances. Finally, we discuss pair creation by photon absorption in the field of a nucleus and a laser, which is related to laser-assisted bremsstrahlung by a crossing symmetry.

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

A 15.3 Mi 12:00 5M

First verification of exceptional points in the spectra of atoms in external fields — •Holger Cartarius, Jörg Main, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart, 70550 Stuttgart

A degeneracy of two complex eigenvalues which has the form of a branch point singularity in systems which depend on a parameter is called an exceptional point. Exceptional points can appear in open quantum systems with resonances, which can be described by complex energy eigenvalues of non-Hermitian Hamiltonians. They have already been studied in a variety of systems, e.g., the laser induced ionization of atoms, acoustical systems, microwave cavities, and atom waves in optical lattices. However, an investigation of the spectra of atoms in external fields with respect to the presence of exceptional points is still lacking.

We report the first observation of exceptional points in the spectrum of the hydrogen atom in static external fields with numerical calculations. For that purpose, we investigate the resonances of the hydrogen atom in crossed electric and magnetic fields and show how exceptional points can be found by exploiting characteristic properties of the branch point singularities. We propose a method to extract resonances from experimental photoionization spectra and to verify the existence of exceptional points experimentally.

A 15.4 Mi 12:15 5M

Cross section statistics for non-hydrogenic Rydberg atoms in crossed fields — •Javier Madroñero[1], Thomas Gorin[2], Shinosuke Kawai[3], and Andreas Buchleitner[2] — [1]Physic Department, Technische Universität München, München — [2]Max-Planck-Institut für Physik komplexer Systeme, Dresden — [3]Laboratoire de Chimie Theorique, Faculte des Sciences, Universite de Sherbrooke, Quebec, Canada

Fluctuations of the ionization cross section for non-hydrogenic Rydberg atoms in crossed electric and magnetic fields are considered in a regime where the classical dynamics is dominated by chaotic scattering and the quantum mechanical regime shows strongly overlapping resonances. Classical decay rates are computed by direct Monte-Carlo

methods as well as transition state theory, and compared with numerically exact quantum simulations.

A 15.5 Mi 12:30 5M

Test der Lorentz-Invarianz mit einer ^{3}He-Atomuhr — •Claudia Gemmel[1], Werner Heil[1], Stefan Baessler[1], Yuri Sobolev[1], Wolfgang Kilian[2], Allard Schnabel[2], Frank Seifert[2], Lutz Thrams[2], Martin Burghoff[2] und Wolfgang Müller[2] — [1]Universität Mainz — [2]PTB Berlin

Ziel des Experimentes ist es, eine Variation der Präzessionsfrequenz der ^{3}He-Spins mit der Periode eines Sternentages zu messen, was eine Verletzung der Lorentz-Invarianz bedeuten würde. In einem schwachen und sehr homogenen Magnetfeld, das in einem magnetisch abgeschirmten Raum an der PTB Berlin aufgebaut wird, werden die ^{3}He-Atome kernspinpolarisiert und zur Spinpräzession angeregt. Die Präzessionsfrequenz wird mit einem SQUID-System über einen Zeitraum von etwa einem Tag aufgezeichnet. Die Messungen werden im Vierteljahresrhythmus wiederholt, um zusätzlich die Phasenverschiebung der Tag-Nacht Periode zu messen.

Mit diesem Aufbau erreichen wir zurzeit T_2-Relaxationszeiten von mehreren Tagen; die Magnetfelddriften liegen bei etwa 1 pT/h. Die Genauigkeit des Experiments, die momentan vor allem durch die Felddriften limitiert ist, kann zukünftig durch den Einsatz einer zweiten Atomuhr (^{129}Xe-Atomuhr), in ihrer Funktion als Co-Magnetometer, wesentlich verbessert werden.

In meinem Vortrag sollen die bisherigen Messungen und Ergebnisse beschrieben und Ideen zur Verbesserung des Aufbaus vorgestellt werden.

A 15.6 Mi 12:45 5M

The two–photon decay of the aligned hydrogen–like U^{91+} ions — •Lesya Borowska[1,2], Andrey Surzhykov[3], Thomas Stöhlker[4], and Stephan Fritzsche[1] — [1]Universität Kassel, Kassel, Germany — [2]Institute for Nuclear Research, Kyiv, Ukraine — [3]MPI, Heidelberg, Germany — [4]GSI, Darmstadt, Germany

Within the last decade, experiments with highly charged ions are related to the studies of one– or few–electron systems in the strong electromagnetic fields produced by heavy nuclei. In atomic structure studies, the heavy ions provides us with the unique possibility to test quantum electrodynamics. One of the most sensitive probe of quantum electrodynamical and relativistic effects in strong fields is the two–photon decay of the highly charged hydrogen–like ions [1]. Up to the present the initially excited state of these ions was assumed to be *unaligned* in all previous studies on the angular correlation of the two emitted photons. In most experiments this assumption is not well justified since the excited states of the ions are produced more often than not in relativistic ion–atom and ion–electron collisions with a well–defined direction of the incoming ion beam [2]. We present theoretical study of the two–photon decay of the aligned hydrogen–like U^{91+} ions. For these ions we calculated photon–photon angular correlation of the $3d_{5/2} \to 1s_{1/2}$ two–photon decay. We compare our result with *unaligned* case.

[1] S. Fritzsche, P. Indelicato and T. Stöhlker, J. Phys. **B38**, S707 (2005).

[2] Th. Stöhlker *et al*, Phys. Scr. **T110**, 384 (2004).

A 16: Robert-Wichard-Pohl Preisträgervortrag

Zeit: Mittwoch 11:30–12:00 Raum: 6J

Preisträgervortrag A 16.1 Mi 11:30 6J

Atom für Atom zu beherrschbaren Quantensystemen — •Dieter Meschede — Institut für Angewandte Physik, Universität Bonn — Träger des Robert-Wichard-Pohl-Preises

Im Laufe des 20. Jahrhunderts ist unser Verständnis der materiellen Welt durch die Quantenphysik grundlegend transformiert worden. Um die Quantentheorie zu testen und zur Illustration haben Experimentalphysiker über viele Jahrzehnte Methoden entwickelt, um einzelne Quantensysteme zu isolieren und Quantenphänomene in besonderer Reinheit zu beobachten. Seit etwa 1990 werden die Experimentatoren mehr und mehr auch zu „Quanten-Ingenieuren“: Sie konstruieren aus wohlverstandenen, isolierten Quantensystemen komplexere Systeme, die nicht nur die Realisierung neuer funktionaler Systeme z. B. für die Quanteninformationsverarbeitung versprechen, sondern auch helfen sollen, unser Verständnis des Übergangs von den mikroskopischen Eigenschaften einzelner Teilchen zur makroskopischen Welt der Vielteilchensysteme zu verbessern. Gespeicherte neutrale Atome sind ein interessantes System für dieses Projekt, weil einerseits schon gezeigt worden ist, dass sie als einzelne Quantensysteme sehr gut beherrscht werden können, andererseits auch kontrollierte, das heisst schaltbare Wechselwirkungen in einem System aus sehr vielen Atomen schon realisiert worden sind. Es wird vorgestellt, welche Methoden zur Verfügung stehen und welche Chancen neutrale Atome bieten könnten.

A 17: Attosecond Physics (jointly with Q)

Zeit: Mittwoch 14:00–16:00 Raum: 6G

Hauptvortrag A 17.1 Mi 14:00 6G

Multielectron wave-packet propagation for electron dynamics following ionization: Basics and explicit applications — •Alexander Kuleff and Lorenz Cederbaum — Theoretische Chemie, PCI, Universität Heidelberg, Im Neuenheimer Feld 229, 69120 Heidelberg, Germany

An *ab initio* method for multielectron wave-packet propagation is presented [1]. It gives the possibility to describe fully *ab initio* the dynamics of various de-excitation processes taking into account *all* electrons of the system and their correlation. The approach is equally suitable for tracing in real time and space the electron dynamics of both decaying and non-decaying electronic states. As an example for electron dynamics of non-decaying states, the charge migration solely driven by electron correlation and relaxation is studied. The method is also utilized for tracing in time and space the the evolution of the electronic cloud throughout the interatomic Coulombic decay (ICD) process in the rare gas cluster NeAr following Ne2*s* ionization [2].

[1] A. I. Kuleff, J. Breidbach and L. S. Cederbaum, J. Chem. Phys. **123** (2005) 044111.

[2] A. I. Kuleff and L. S. Cederbaum, arXiv:physics/0612061.

A 17.2 Mi 14:30 6G

Attosecond Pulse Trains with Two Colors — •Marko Swoboda[1], Johan Mauritsson[1], Erik Gustafsson[1], Per Johnsson[1], Thomas Remetter[1], Thierry Ruchon[1], Anne L'Huillier[1], and Kenneth Schafer[2] — [1]Department of Physics, Lund University, P.O. Box 118, 221 00 Lund, Sweden — [2]Department of Physics and Astronomy, Louisiana State University, Baton Rouge, Louisiana 70803-4001, USA

We demonstrate how a sequence of identical attosecond pulses created with a two-color laser field can be used to release electron wave packets exactly once per laser cycle. The released electrons can then be used to steer and measure atomic processes on attosecond time scales. The pulses arriving at the frequency of the probing infrared field allow us to compare this to a stroboscope, each pulse identical to previous pulses and repeatedly performing measurements in the exact same conditions. Using this technique, we study the ionization of He in presence of a strong infrared laser field which shifts the electron momentum distribution depending on the vector potential of the light field. In this experiment, Coulomb-refocusing and other atomic effects can be observed from driving the electron wave packets back to the atomic core.

A 17.3 Mi 14:45 6G

Vibration and laser dressing in molecular high-harmonic generation — •Ciprian Chirila and Manfred Lein — Universität Kassel, Fachbereich Physik 18, Heinrich-Plett-Str. 40, 34132 Kassel

We study high-harmonic generation in the H2 molecule, and its heavier isotope, D2, exposed to an intense, low-frequency laser pulse. The molecular vibration is taken into account. We investigate the effect of laser dressing of the two lowest-laying Born-Oppenheimer potentials in the molecular ion formed upon ionizaton. Conclusions are drown about the laser-frequency range and the range of molecular orientations where the dressing becomes relevant to the process.

A 17.4 Mi 15:00 6G

Attosecond scattering of particles from quantum correlated condensed systems — •Chariton Aris C.-Dreismann — Institut für Chemie, TU Berlin, Sekr. C2, 10623 Berlin

Nuclei and electrons in condensed matter are usually entangled, due to the electromagnetic interaction. However, strong couplings with the "environment"cause an ultrafast decoherence, thus making entaglement effects not accessible to experiments. Recently, neutron [1a] and electron [1b,2] Compton scattering experiments from protons (H-atoms) in several condensed systems at room temperature demonstrated a striking effect, i.e. an "anomalous"decrease of scattering intensity. Due to the large energy (several eV) and momentum (20- 200 $\AA^{-1}$) transfers of these experiments, is the collisional (or scattering) time between the probe particle and the proton $100-1000$ as. The considered effect, which has no interpretation within conventional neutron scattering theory, is caused by the non-unitary quantum dynamics (due to decoherence) during the ultrashort, but finite, time-window of the scattering process. Examples of experimental results will be shown, and a theoretical outline "from first principles"[3] will be presented.

[1] C. A. C.-Dreismann et al., (a) Phys. Rev. Lett. 79, 2839 (1997); (b) Phys. Rev. Lett. 91, 057403 (2003). [2] Physics Today, p. 9,(Sept. 2003). [3] C. A. C.-Dreismann and S. Stenholm, in preparation.

A 17.5 Mi 15:15 6G

Sub-cycle dynamics in the laser ionization of molecules — •Xinhua Xie, Marlene Wickenhauser, and Armin Scrinzi — TU Wien, Institut f. Photonik

During a single optical cycle of a strong laser pulse, electrons are driven out of a molecule, accelerated, and directed back onto their parent molecule, where they scatter or recombine. We present a precise definition of "emission time" and initial momentum distribution in the framework of the time-dependent Schrödinger equation (TDSE). Solving the TDSE numerically for two-dimensional model molecules, we find that electron emission from and re-collision with the molecule can develop pronounced time-structures that strongly depend on the molecular species, molecular orientation, and on laser intensity. The peak of emission can shift through a significant fraction of laser cycle. The structures are produced by laser-induced intra-molecular electron dynamics. The importance of these findings for high harmonic generation and molecular tomography will be discussed.

A 17.6 Mi 15:30 6G

Heterodyne control of attosecond pulse generation — •Thomas Pfeifer[1,2], Lukas Gallmann[1,2], Mark J. Abel[1,2], Phillip M. Nagel[1,2], Aurélie Jullien[1,2], Daniel M. Neumark[1,2], and Stephen R. Leone[1,2] — [1]Departments of Chemistry and Physics, University of California, Berkeley, CA 94720, USA — [2]Chemical Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

Adding a weak laser field at a different color to the fundamental in high-order harmonic generation results in a new type of heterodyne mixing in the kinetic energy term of the active electron. Analytical calculations and quantum simulations show that the effect of the weak field is amplified by the strong fundamental laser field that acts as the local oscillator [1]. The photon energies of different attosecond pulses within the produced pulse trains can thus be significantly modified. Two important applications for this phenomenon are the generation of isolated attosecond pulses with multi-cycle driving fields and the shaping of attosecond pulse trains.

Ref.: [1] T. Pfeifer et al., Phys. Rev. Lett. **97**, 163901 (2006)

A 17.7 Mi 15:45 6G

High Harmonic Generation for attosecond pump-probe experiments — •Helga Rietz, Konstantin Simeonidis und Joachim Ullrich — Max-Planck-Institut für Kernphysik, 69117 Heidelberg

The generation of high harmonic (HHG) radiation in rare gases using ultrashort infrared laser pulses is a well proven method to provide an efficient way to produce attosecond light pulses, thus opening the door to direct investigation of dynamics on attosecond timescales, such as the electronic motion in atoms.

Here we report on the construction of the first stage of a new experiment that will combine attosecond light pulses from HHG with a so called "reaction microscope" to perform pump-probe measurements with attosecond resolution on atoms and molecules. An innovative, versatile vacuum chamber housing all necessary optics, a gas target for HHG and a spectrometer setup for XUV-characterisation have been designed and successfully put into operation. The harmonics are generated using 800nm Ti:Sapphire laser pulses produced by a commercially available Ti:Sa-amplifier system at a pulse repetiton frequency of 10 kHz, with a single pulse energy of 0.7 mJ and duration of approximately 25 fs. A further compression to 6 fs is planned. Particularly, the high repetition rate of the system is expected to increase experimental sensitivity. First examinations of the harmonics produced in Argon and Neon exhibit a promising yield of coherent soft-X-ray radiation and confirm our setup.

A 18: Interaction with VUV and X-Ray light

Zeit: Mittwoch 16:30–18:30 Raum: 6G

Hauptvortrag A 18.1 Mi 16:30 6G

Röntgen-Laserspektroskopie mit hochgeladenen Ionen am Freie-Elektronen-Laser FLASH — •José Crespo López-Urrutia, Sascha Epp und Joachim Ullrich — Max-Planck-Institut für Kernphysik, Heidelberg

Seit dem Jahr 2006 bietet FLASH (Free electron LASer in Hamburg) Laserstrahlung sehr hoher Intensität im weichen Röntgenbereich bis 90 eV für Experimente an. In Kombination mit hochgeladenen Ionen in einer mobilen EBIT (electron beam ion trap, Elektronenstrahl-Ionenfalle) ist es nunmehr auch möglich, Übergänge zwischen gebundenen Niveaus in diesem Energiebereich durch Resonanzfluoreszenz zu untersuchen. Die in diesen Ionen erforschten Linien enthalten quantenelektrodynamische Beiträge, wie z. B. die Lamb-Verschiebung, von bis zu 1% der Übergangsenergie. Die Ergebnisse von diesem sowie von anderen Präzisionsexperimenten an der Heidelberger EBIT gestatten somit eine kritische Überprüfung aktueller theoretischer Vorhersagen über die Physik in den höchsten elektromagnetischen Feldern bei denen gebundene Elektronen vorkommen.

A 18.2 Mi 17:00 6G

Ionisationsdynamik von dotierten Edelgasclustern im Strahlungsfeld des FLASH VUV-FEL — •Heiko Thomas[1], Christoph Bostedt[1], Matthias Hoener[1], Ekaterina Eremina[1], Hubertus Wabnitz[2], Tim Laarmann[3] und Thomas Möller[1] — [1]TU Berlin — [2]DESY Hamburg — [3]MBI Berlin

Ein detailliertes Verständnis der Wechselwirkung zwischen kurzwelliger, ultra-intensiver Strahlung und Materie ist sowohl für die Grundlagenforschung als auch für zukünftige Experimente mit Freie-Elektronenlaser (FEL) von grosser Bedeutung. Experimente hierzu sind typischerweise an homonuklearen Systemen durchgeführt worden. In solchen Systemen konnten allerdings keine Aussagen über ortsabhängige Mechanismen für die Entstehung hoher Ladungszustände, wie z.B. Feldionisation an der Clusteroberfläche getroffen werden.

Wir haben Experimente über die Ionisationsdynamik an dotierten Edelgasclustern mit FEL Strahlung durchgeführt. Dafür wurden Ar Cluster entweder im Volumen oder auf der Oberfläche mit Xe Atomen dotiert. Die Xe Atome wurden mit FEL Strahlung bei 13.7 nm in der Xe 4d Riesenresonanz angeregt, wodurch ein großer Anregungskontrast zwischen dem Xe Dopant und dem Ar Wirtscluster erreicht werden konnte. Erste Ergebnisse zeigen, daß ein effektiver Ladungs-

transfer zwischen Oberflächendotierungen und dem Wirtscluster statt findet und Mischfragmente abgespalten werden.

A 18.3 Mi 17:15 6G

Investigation of the fragmentation processes in rare gas cluster with a reaction microscope — •Matthias Hoener[1], Christioph Bostedt[1], Lutz Foucar[2], Heiko Thomas[1], and Thomas Möller[1] — [1]Institut für Optik und Atomare Physik, TU Berlin — [2]Institut für Kernphysik, Universität Frankfurt

The investigation of ioniziation and fragmentation processes with reaction microscopes based on the Coltrims (cold target recoil ion momentum spectrsoscopy) technique has developed into a vivid field of research in atomic physics. We have applied the momentum resolving Coltrims technique to study the fragmentation dynamics of clusters. The clusters were excited with 80 and 700eV photons. This way different numbers of average charges, 3 and 7 respectively, can be generated on the cluster. The ionic fragments from the reaction were measured in coincidence with the photoelectrons. Depending on the photon energy and thus number on charges the reaction-patterns look significantly different. For small cluster irradiated with 700eV photons the monomers, i.e., singly charged Xe-atoms are the dominant fragments. They exhibit a significant amount of momentum, which they gained during the coulombic repulsion with the other ionic cluster atoms. In contrast, large cluster irradiated by 80eV photons behave completely different. The reduced number of ions in the large cluster leads only to fission into large fragments. The observations that multicharged cluster explode and singly charged cluster break, are consistent with theoretical predictions. We thank the group of H. Schmidt-Böcking and R. Dörner from the Universität Frankfurt for their support.

A 18.4 Mi 17:30 6G

High harmonic generation from laser driven muonic atoms — •Atif Shahbaz[1], Carsten Müller[1], Andreas Staudt[1], Thomas J. Bürvenich[2], and Christoph H. Keitel[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Frankfurt Institute for Advanced Studies, Johann Wolfgang Goethe University, Max-von-Laue-Str. 1, 60438 Frankfurt am Main

High harmonic generation from muonic atoms in intense VUV laser fields is considered [1]. Our particular interest lies in the effects arising from the finite nuclear mass and size. We study these effects numerically by employing modified soft-core and hard-core potentials. We show that the position of the high-energy cutoff of the harmonic spectrum depends on the nuclear mass, while the height of the spectral plateau is sensitive to the nuclear radius.

[1] A. Shahbaz, C. Müller, A. Staudt, T. J. Bürvenich and C. H. Keitel, in preparation.

A 18.5 Mi 17:45 6G

Probing the cluster dynamics with atto-second XUV laser pulses — •Ionuţ Georgescu, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzerstr. 38, 01187 Dresden, Germany

Xenon clusters have been exposed to short intense laser pulses at 98nm wavelength within the first testing stages of the upcoming X-Ray Free Electron Laser at DESY, Hamburg. The experiment [1] has shown an unexpectedly effective energy absorption mechanism resulting into Coulomb explosion of the clusters with high measured ionic charge states.

Several theoretical models [2-5] have managed to explain the outcome of the experiments, but they all disagree on the internal mechanisms of the energy absorption. We propose here a pump-probe scheme with atto-second XUV laser pulses which would offer a time resolved picture of the transient ionic charge states in the cluster.

[1] H. Wabnitz et.al., Nature 420, 482 (2002)
[2] R. Santra and C.H. Greene, PRL 91, 233401 (2003)
[3] C. Siedschlag and J.M. Rost, PRL 93, 043402 (2004)
[4] C. Jungreuthmayer et.al., J. Phys. B 38, 3029 (2005)
[5] M. Rusek and A. Orlowski, PRA 71, 043202 (2005)

A 18.6 Mi 18:00 6G

Core-Level Photoelectron Spectroscopy on Mass-Selected Lead Clusters using VUV-FEL Radiation — Volkmar Senz[1], •Tim Fischer[2], Patrice Oelssner[1], John Neville[3], Markus Schöffler[4], Jörg Stanzel[5], Heiko Thomas[6], Matthias Neeb[5], Josef Tiggesbäumker[1], Michael Martins[7], Eckart Rühl[8], Christoph Bostedt[6], Wolfgang Eberhardt[5], Gerd Ganteför[2], Thomas Möller[6], Horst Schmidt-Böcking[4], Reinhard Dörner[4], Wilfried Wurth[7], and Karl-Heinz Meiwes-Broer[1] — [1]Universität Rostock — [2]Universität Konstanz — [3]University of New Brunswick, Canada — [4]Universität Frankfurt am Main — [5]BESSY Berlin — [6]Technische Universität Berlin — [7]Universität Hamburg — [8]Freie Universität Berlin

Metal clusters are known to exhibit new and interesting catalytic, chemical and magnetic properties. In particular, the number of atoms has a pronounced influence on the electronic and geometric structure.

A promising method to study these variations is VUV photoelectron spectroscopy of mass selected clusters. However, for investigation of the complete valence band and shallow core levels, no photon source except the free-electron-laser FLASH at HASYLAB/DESY is available at the moment. Only this source provides the appropriate radiation of several tens of eV with sufficient high photon flux.

First promising results, featuring a size-dependent core-level shift, have been obtained.

A 18.7 Mi 18:15 6G

Soft X-ray Ion Yield Spectroscopy of Neutral Transition Metal Clusters — •Tobias Lau[1], Jochen Rittmann[1], Theresa Schadow[1], Marlene Vogel[1], Vicente Zamudio-Bayer[1], Max Feucker[1], Marko Härtelt[1], Fabian Lofink[1], Bernd von Issendorff[2], and Thomas Möller[1] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, PN 3-1, Hardenbergstraße 36, D-10623 Berlin — [2]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg

Core level spectroscopy is a valuable tool to study the local electronic density of states with element specificity. Recently, mass resolved ion yield spectra of neutral transition metal clusters after core level excitation at their $L_{2,3}$ edges have been measured at BESSY. The basic concept of the experiment will be outlined and relevant details of the method will be discussed in view of first results.

The transition from atomic to bulk-like core-level excitation spectra is studied as a function of cluster size for Ti, V, Cr, Co, and Ni clusters. Preliminary analysis of $L_{2,3}$ line shapes and branching ratios indicates that this transition takes place already in small transition metal clusters with a size around 50 atoms per cluster. In the X-ray absorption process, core level excitation and subsequent relaxation lead to cluster fragmentation and to multiply charged clusters. As a result, apparent changes in the cluster size distribution are observed. Cluster fragmentation and ionization are analyzed as a function of cluster size in the vicinity of the $L_{2,3}$ edges.

A 19: Photoionization

Zeit: Donnerstag 11:30–13:00 Raum: 5M

Hauptvortrag A 19.1 Do 11:30 5M

Photophysics of DNA: Relation between structure and dynamics in isolated clusters — •Thomas Schultz[1], Elena Samoylova[1], Hans-Hermann Ritze[1], Wolfgang Radloff[1], Yuliya Rulyk[1], and Ingolf Volker Hertel[1,2] — [1]Max-Born-Institut Berlin, Max-Born-Str. 2A, 12489 Berlin — [2]Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin

The photophysics of DNA is governed in part by intrinsic properties of the DNA bases, but also by intermolecular interactions with the local environment. Investigation of the latter is particularly difficult due to the multitude of relevant noncovalent interactions and the intimate relationship between the local structure and the position and shape of excited state potential energy surfaces, which determine the outcome of excited state dynamic processes.

We reduce this complexity by investigating the photophysics in small, isolated molecular clusters, e.g. hydrogen-bound or stacked base pairs and microhydrated bases. Pump-probe photoionization spectroscopy identified ultrafast processes involving bright and dark elec-

tronic states, a hydrogen transfer reaction and delocalized excimer states. Most observed processes lead to ultrafast excited state relaxation and help to explain the extraordinary photostability of DNA. Comparison to ab initio calculations offered insight into the importance of particular interactions such as specific hydrogen bonds or the environment polarizability. Small clusters with suitable geometry seem to reproduce processes in real DNA and may extend our detailed understanding of isolated molecules towards complex biological systems.

A 19.2 Do 12:00 5M

Photoionization sequences of multi-ionic neon — •Bernd Lohmann[1,2], Ulrich Kleiman[3], Markus Braune[2], Axel Reinköster[2], Burkhard Langer[4], and Uwe Becker[2] — [1]Institut für Theoretische Physik, Universität Münster, 48149 Münster — [2]Fritz-Haber-Institut der MPG, 14195 Berlin — [3]MPI für Physik Komplexer Systeme, 01187 Dresden — [4]MBI für Nichtlineare Optik und Kurzzeitspektroskopie, 12489 Berlin

The thriving results currently emerging from the free electron laser FLASH for the multi-photoionization of ions require for a theoretical interpretation. In a first attempt, we are employing the semi-relativistic Hartree-Fock code of Cowan [1] combined with the schemes of Racah algebra and fractional parentage [2], in order to relate the open-shell dipole transition matrix elements with the one electron dipole matrix elements provided by the Cowan code. First numerical cross section results for selected ionic photoionization sequences of neon will be presented.

[1]Cowan, R. D. (1981). "The Theory of Atomic Structure and Spectra." UCLA Press, Berkeley, Los Angeles, London.

[2]Racah, G. (1942). Phys. Rev. 62, 438.

A 19.3 Do 12:15 5M

Interferenzeffekte in der Photoionisation von H_2 — •Axel Reinköster[1], Markus Braune[1], Rainer Hentges[1], Sanja Korica[1], Jens Viefhaus[1], Ralph Püttner[2], Burkhard Langer[3] und Uwe Becker[1] — [1]Fritz-Haber-Institut der MPG, Faradayweg 4-6, 14195 Berlin — [2]Freie Universität Berlin, Institut für Experimentalphysik, Arnimallee 14, 14195 Berlin — [3]Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie, Max-Born-Str. 2a, 12489 Berlin

Molekularer Wasserstoff ist der Prototyp für das Auftreten von Interferenzen in der Photoelektronenemission analog zum Young'schen Doppelspaltexperiment mit Lichtwellen. Die richtungsaufgelöste Photoelektronenspektroskopie im molekularen Bezugssystem offenbart diesen Effekt besonders deutlich. Die Experimente wurden bei BESSY in Berlin durchgeführt. Von besonderem Interesse war in diesem Zusammenhang die Frage, ob die modifizierte Cohen-Fano Oszillation als Ausdruck der Interferenz der beiden Photoelektronenwellen exakt mit der zur Bindungslänge des H_2 Moleküls proportionalen Frequenz auftreten würde. Da die Einfach-Photoionisation von H_2 zu dem stabilen Molekülion H_2^+ führt, stehen für winkelaufgelöste Elektron–Fragmention-Koinzidenzexperimente nur Photoelektronen-Satellitenlinien zur Verfügung. Die normierte Satellitenlinienintensität bei geringster kinetischer Energie zeigt eine deutliche Oszillation mit einer Frequenz, die genau der Bindungslänge von H_2 entspricht. Darüber hinaus tritt bei einer de Broglie Wellenlänge von λ=4R eine markante Shaperesonanz auf, die bisher so weder beobachtet noch diskutiert worden ist.

A 19.4 Do 12:30 5M

Symmetrie- und Interferenzeffekte in der Photoionisation von Fullerenen — •Uwe Becker[1], Sanja Korica[1], Axel Reinköster[1], Markus Braune[1], Rainer Hentges[1], Jens Viefhaus[1] und Burkhard Langer[2] — [1]Fritz-Haber-Institut der MPG, Faradayweg 4-6, 14195 Berlin — [2]Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie, Max-Born-Str. 2a, 12489 Berlin

Fullerene, insbesondere C_{60} und C_{70}, zeigen ausgeprägte Oszillationen ihrer partiellen Photoionisations-Wirkungsquerschnitte, bedingt durch die Interferenz zwischen verschiedenen Wegen, die das Photoelektron von verschiedenen Emissions-Orten auf der delokalisierten Ladungsschale nehmen kann. Das Verzeigungsverhältnis zwischen den beiden ungeraden und geraden Valenzorbitalen HOMO und HOMO-1 ist ein besonders sensitiver Indikator für das Auftreten dieser Oszillationen. Trägt man die normierten Wirkungsquerschnitte über den Impulsvektor K(D^{-1}) in Einheiten des inversen Durchmessers von C_{60} auf, so sieht man, dass die de Broglie Wellenlänge λ=D genau einer vollen Periode von 2π in K entspricht. Dies ist genau das gleiche Verhalten wie es für homonukleare zweiatomige Moleküle wie H_2 und N_2 beobachtet wird. Es ist die von Cohen und Fano vorhergesagte doppelspaltartige Interferenz der beiden von zwei kohärenten Emitterpunkten auslaufenden Photoelektronen. Um dieses Modell auf die Fullerene anwenden zu können, muss man die kohärenten Emitter-Punkte nur durch eine kohärente Emitter-Schale ersetzen. Dies erklärt insbesondere die Interpretation der Oszillationsminima als stehende Wellen.

A 19.5 Do 12:45 5M

Above threshold interchannel coupling effects in the Cs 3d spin orbit doublet — •Tobias Richter[1], Elke Heinecke[1], Peter Zimmermann[1], Kai Godehusen[2], Methap Yalçinkaya[3], Denis Cubaynes[4], and Michael Meyer[4] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, Berlin, Germany — [2]BESSY GmbH, Berlin, Germany — [3]Istanbul University, Physics Department, Istanbul, Turkey — [4]LIXAM, Orsay, France

The asymmetry parameter β and partial cross section σ of Cs $3d_{5/2}$ photo electrons were investigated near the threshold of the $3d_{3/2}$ channel at about 750 eV. The interchannel coupling has a dramatic influence on $\beta_{5/2}$ in the energy region where the mixing with the $3d_{3/2}$ channel produces a pronounced minimum in the partial cross section $\sigma_{5/2}$. Obviously the phase difference of the outgoing p and f waves dominates the behaviour of $\beta_{5/2}$ there. This above threshold effect is activated by the spin orbit interaction.

A 20: Atomic Systems in External Fields II

Zeit: Donnerstag 11:30–13:15 Raum: 6G

Hauptvortrag A 20.1 Do 11:30 6G

Controlling Ultracold Rydberg Atoms in the Quantum Regime — •Igor Lesanovsky — Institut für Quantenoptik und Quanteninformation, Universität Innsbruck, Austria

Controlling the external quantum state of ultracold ground state atoms by means of magnetic fields is nowadays a well-established experimental technique. Even in steep magnetic traps the inhomogeneous field varies on scales much larger than the extension of an atom. Hence, atoms can be regarded as point-particles exposed to a quasi-homogeneous field. For Rydberg atoms whose size can be of the order of micrometers this is no longer the case and consequently the internal atomic structure must be taken into account. Therefore it is difficult to make a priori predictions on whether trapping is possible or not. By solving the Schrödinger equation we demonstrate that bound states of the center of mass motion of Rydberg atoms exist in standard magnetic traps. We illuminate a novel class of states where the extension of the electronic Rydberg wave function becomes equal to or even exceeds the size of the center of mass state and outline a way to generate a low-dimensional ultracold Rydberg gas.

[1] I. Lesanovsky and P. Schmelcher, PRL 95, 053001 (2005)

[2] I. Lesanovsky and P. Schmelcher, PRA 72, 053410 (2005)

[3] B. Hezel, I. Lesanovsky and P. Schmelcher, PRL 97, 223001 (2006)

A 20.2 Do 12:00 6G

Evidence for laser-induced relaxation in metastability exchange (ME) optical pumping (OP) of ^{3}He — •Marion Batz[1], Werner Heil[1], Pierre-Jean Nacher[2], and Geneviève Tastevin[2] — [1]Universität Mainz — [2]Laboratoire Kastler Brossel, Paris

To understand current limitations of ^{3}He MEOP, we perform systematic studies of 2^3S-2^3P$_0$ pumping below 30mT. Experimentally, the time evolution of the nuclear polarisation M is monitored as a function of gas pressure (0.65-2.6 mbar), discharge intensity, power (0-5W) and tuning of the pump laser. An OP model is used to compute the laser-driven 2^3S and 2^3P populations and the evolution of M under combined OP, ME, and relaxation processes. Pump absorption and M growth rates measured at M=0 provide accurate relaxation-independent data to quantitatively validate the model. During M build-up, however, ex-

perimental growth rates decrease faster than expected, and systematically lower steady-state Ms are measured. To account for this, relaxation rates must be used in the model that exceed those measured in the plasma (pump off) by up to two orders in magnitude. The required additional relaxation rates are found to be proportional to the absorbed laser powers. We can directly measure the actual relaxation rates for C_8 pumping (2^3S, F=1/2 - 2^3P_0), the net loss of angular momentum being simply equal to the difference between the deposited one (absorbed power) and the stored one (M growth) for single-component excitation. Potential contribution of laser-enhanced relaxation processes, such as radiation trapping or collisions with metastable He_2^* molecules (more likely formed from 2^3P states), will be investigated.

A 20.3 Do 12:15 6G

A control of creating narrow wave packet via atom scattering by a chirped standing light wave — •Maxim A. Efremov[1,4], Mikhail V. Fedorov[1], Valeri P. Yakovlev[2], Markus K. Oberthaler[3], and Wolfgang P. Schleich[4] — [1]General Physics Institute, RAS, Moscow, Russia — [2]Moscow Engineering Physics Institute (State University), Moscow, Russia — [3]Kirchhoff-Institut für Physik, Universität Heidelberg, Heidelberg, Germany — [4]Institut für Quantenphysik, Universität Ulm, Ulm, Germany

We investigate the formation of narrow wave packets in the process of atomic scattering at a resonant standing light wave. One way to provide such a narrowing effect was described theoretically in our earlier works [1] and confirmed successfully by Stützle et al. [2]. Here we suggest and describe an alternative approach: we consider a chopped standing light wave and the intra-atomic excitation due to the adiabatic inversion of levels. Because of the intimate connection between the internal and external variables of atomic motion the adiabatic passing results in the formation of narrow atomic wave packets. The method provides an easy control of three important parameters: (i) the position of creation, (ii) the time interval, during which the absorption process plays a crucial role, and (iii) the final size of the wave packet. All of these parameters are determined only by the chirped pulse parameters.

[1] M.A. Efremov et al., Laser Phys. 13, 995 (2003); M.V. Fedorov et al., JETP 97, 522 (2003).
[2] R. Stützle et al., Phys. Rev. Lett. 95, 110405 (2005).

A 20.4 Do 12:30 6G

Noise induced ionization and dissociation of diatomic molecules — •Anatole Kenfack[1], Frank Grossmann[2], and Jan-Michael Rost[1] — [1]Max-Planck Institute for the Physics of Complex Systems, D-01187 Dresden, Germany — [2]Institute for Theoretical Physics, Dresden University of Technology, D-01062 Dresden, Germany

A quantum system can efficiently absorb energy from a noise source. We have demonstrated this effect in the noise induced dissociation of polar diatomic molecules[1]. In a second step we investigate, beyond the Born-Oppenheimer approximation, the competition between ionization and dissociation of the Hydrogen molecular ion (H2+) exposed to the same noise of source. The time dependent Schroedinger equation is solved for a three dimensional H2+ system with two electronic and one vibrational degrees of freedom. We show that by appropriately choosing the noise kicking period, with respect to other time scales of the system, one can selectively ionize or dissociate H2+. This selectivity is difficult to achieve with the use of laser fields [2,3].

[1] A. Kenfack and J.M. Rost, J. Chem. Phys. 123, 204322 (2005)
[2] S. Chelkowski, A. Bandrauk, and P.B. Corkum, Phys. Rev. Lett. 65, 2355 (1990)
[3] J. H. Kim, W. K. Liu, F. R. W. McCourt and J. M. Yuan, J. Chem. Phys. 112, 1757 (2000)

A 20.5 Do 12:45 6G

Time-dependent density functional theory: Causality and other problems — •Michael Ruggenthaler and Dieter Bauer — Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg

Time-dependent density functional theory (TDDFT) is a reformulation of the time dependent many-body problem in quantum mechanics which is capable of reducing the computational cost to calculate, e.g., strongly driven many-electron systems enormously. Recent developments were able to overcome fundamental problems associated with ionization processes [1,2]. Still vital issues have to be clarified. Besides the construction of the underlying functionals we investigate the causality problem of TDDFT by general considerations and by studying a exactly solvable system of two correlated electrons in an intense laser-pulse. For the latter system, the two alternative approaches to the construction of the action functional or a constrained functional derivative by van Leeuwen [3] and Gál [4], respectively, are explored.

[1] M. Lein and S. Kümmel, Phys. Rev. Lett. **94**, 143003 (2005).
[2] F. Wilken and D. Bauer, Phys. Rev. Lett. **97**, 203001 (2006).
[3] R. van Leeuwen, J. Mod. Phys. **15**, 1969 (2001).
[4] T. Gál, J. Phys. A: Math. Gen. **35**, 5899 (2002).

A 20.6 Do 13:00 6G

Plasma-Satelliten aufgrund von evaneszenten Wellen und Langmuir-Oszillationen in der Hohlkathode — •Johannes Hildebrandt — GISES GmbH, Gesellschaft für Informationssysteme, Engineering und Service, D-45527 Hattingen

Die Messung von Plasma-Oszillationen über den HF Stark-Effekt wurde bereits 1961 von Baranger und Mozer vorgeschlagen. Hildebrandt und Kunze gelang 1980 der erste Nachweis von Plasma-Satelliten einer verbotenen Komponente im optischen Spektrum der He I Linie bei 447 nm (Phys.Rev.Lett. 45, 183 (1980)). Erst kürzlich konnten die genauen Vorgänge in der verwendeten Hohlkathodenquelle im Detail analysiert werden (J. Hildebrandt, J.Phys.D 39, 3625 (2006)). Die zugehörige 2-Quanten-Theorie ist intensiv diskutiert worden (E. Oks, Plasma Spectroscopy, V. 9 (Springer; Berlin 1995)), und dieser Vortrag stellt eine Antwort auf die dort erhobenen Einwände dar. Beide Ansätze, sowohl die Dirac'sche Störungstheorie mit sich langsam entwickelnden Zustandsvektoren, als auch die Multi-Satellitentheorie von Hicks, Hess und Cooper (Phys. Rev. A 5, 490 (1972)) mit schnell drehenden Entwicklungstermen bei der Feldfrequenz, werden über passende Koeffizienten in der zeitabhängigen Schrödingergleichung miteinander vereint. Damit ist die Analogie zum Matrixprodukt (J. Hildebrandt, Opt.Lett. 10, 541 (1985)) bei niedrigen Feldstärken hergestellt. Als wichtigstes Ergebnis wird eine Schwellwert-Feldstärke vorgestellt, ab der auch longitudinale Felder über ein definiertes dielektrisches Modenvolumen erfasst werden. Es wird ein Bezug zu aktuellen Messungen hergestellt (N. C. Woolsey et al, JQSRT 99, 680 (2006)).

A 21: Innovative Traps and Cooling Schemes (jointly with Q)

Zeit: Donnerstag 14:00–16:00 Raum: 5D

A 21.1 Do 14:00 5D

Time-Averaged Adiabatic Potentials: Novel traps and waveguides for ultracold quantum gases — •Wolf von Klitzing and Igor Lesanovsky — Institute of Electronic Structure and Laser, Foundation for Research and Technology -Hellas, P.O.Box1527, GR-71110 Heraklion, Greece

We demonstrate a novel class of trapping potentials, time-averaged adiabatic potentials (TAAP) which allows the generation of a large variety of traps and waveguides for ultracold atoms. Multiple traps can be coupled through controllable tunneling barriers or merged altogether. We present analytical expressions for pancake-, cigar-, and ring- shaped traps. The ring-geometry is of particular interest for guided matter-wave interferometry as it provides a perfectly smooth waveguide of controllable diameter, and thus a tunable sensitivity of the interferometer.

[1] I. Lesanovsky and W. von Klitzing, preprint: cond-mat/0612213 (2006)

A 21.2 Do 14:15 5D

Ultra-cold strontium atoms for optical frequency metrology — •Joseph Sundar Raaj Vellore Winfred, Thomas Legero, Fritz Riehle, and Uwe Sterr — Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Precise measurement of time is of paramount importance in technological and scientific endeavors. Recent advancement in optical frequency metrology promises to measure time with a fractional accu-

racy of 10^{-17}. Strontium is an attractive candidate for such an optical clock because of its narrow line transition with a linewidth of about 1 mHz and the existence of a magic wavelength for the clock transition in the NIR region. Here we report preliminary results of cooling and trapping of strontium atoms. The strontium atoms are cooled down to ultra-cold temperature regime(2 μK) in a two-stage cooling process. An overview of our experimental set up, characterization of a 1-D optical dipole trap with respect to different trap parameters and its relevance to frequency measurement will be presented.

A 21.3 Do 14:30 5D

Auf dem Weg zu wenigen fermionischen Atomen in einer Mikrofalle — •Friedhelm Serwane[1], Timo Ottenstein[1] und Selim Jochim[1,2] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Fakultät für Physik und Astronomie, Universität Heidelberg

Wir berichten über die Planungen für ein Experiment zur Präparation eines Systems bestehend aus einer deterministischen Anzahl von fermionischen ^{6}Li-Atomen im Grundzustand einer optischen Mikrofalle. Mittels einer Feshbachresonanz kann die Wechselwirkung zwischen Teilchen in unterschiedlichen Spinzuständen frei eingestellt werden. Auf diese Weise kann die Physik weniger wechselwirkender Fermionen untersucht werden, die auch die Eigenschaften von Kernen und Atomen entscheidend bestimmt. Besonders interessant erscheint dabei auch die Möglichkeit, exotische Konfigurationen nach Belieben zu präparieren, wie sie zum Beispiel als Halokerne in der Kernphysik studiert werden. Ausgangspunkt für diese Experimente wird ein molekulares Bose-Einstein-Kondensat von $^6Li_2$-Molekülen sein, mit dem eine ausreichend niedrige Temperatur erreicht werden kann, bevor dann die meisten Teilchen durch kontrolliertes Absenken des Fallenpotentials entfernt werden.

A 21.4 Do 14:45 5D

Noise reduction in a cold atomic trapped sample — •Jerome Esteve, Andreas Weller, Jens Appmeier, Christian Gross, Rudolf Gati, and Markus Oberthaler — Kirchhoff Institut für Physik, Im Neuenheimer Feld 227, 69120 Heidelberg

In typical cold atom experiments, the fluctuations of the total atom number in the trap are dominated by technical fluctuations and are usually bigger than shot-noise. Reducing these fluctuations as much as possible is of great interest for numerous experiments. In particular, it is a prerequisite to the generation of entangled states in Bose-Einstein condensates since many entanglement schemes rely on the knowledge of the absolute atom number. In this presentation, we will show experimental results where the total atom number fluctuations in an optical dipole trap are strongly reduced down to approximately the shot-noise level by introducing three body losses in the sample. We will discuss the minimal noise that can be achieved by this method and show that sub-shot-noise fluctuations should indeed be observable.

A 21.5 Do 15:00 5D

Laser Cooling of Barium — •Subhadeep De, Umakanth Dammalapati, Klaus Jungmann, and Lorenz Willmann — 1KVI, University of Groningen, 9747 AA Groningen, The Netherlands

Heavy alkaline earth elements like radium offer unique possibilities to test fundamental symmetries in nature. This has triggered the interest in laser cooling and trapping of such isotopes. We have developed strategies for laser cooling with barium, which exhibits a very similar level scheme. These isotopes suffer from large losses from the strong 1S0-1P1 cooling transition to metastable D-states. The branching ratio to the 1D2, 3D2, 3D1-states is 330:1 for barium and similar for radium. We have performed the first laser spectroscopy of the 1D2, 3D2, 3D1 to 1P1 repumping transitions in barium. With the repumpers (1108nm, 1130nm, 1500nm) we were able to demonstate the first laser cooling of barium, where we reduced the loss to the metastable state to less than 1 in 10000. This allow to slow an atom by more than 100m/s. In addition, we are investigating other schemes for repumping in barium. We plan to apply these results to laser cooling of radium.

A 21.6 Do 15:15 5D

Atomfalle im Internet — •Anika Vogel, Greta Johannsen, Kai Bongs und Klaus Sengstock — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

Die Physik kalter atomarer Gase findet weltweit größtes Interesse in Grundlagenforschung und Anwendung und wurde 1997 mit dem Nobelpreis gewürdigt. Um dieses Gebiet für Studenten (und potentiell Schüler) aller Welt zugänglich und aktiv erfahrbar zu machen, erstellen wir derzeit ein reales Experiment zur magnetooptischen Speicherung von Rubidium-87-Atomen, das wir in einem Internetportal mit interaktiv steuerbaren experimentellen Parametern zugänglich machen wollen. Lernmodule sollen ein Verständnis der Laserkühlung mit detaillierten Texten zu den theoretischen Grundlagen sowie mit Animationen und Simulationen zum Thema ermöglichen. In diesem Vortrag wird der experimentelle Aufbau und der aktuelle Stand der Arbeiten vorgstellt. Das Projekt wird vom Multimediakontor Hamburg gefördert.

A 21.7 Do 15:30 5D

Electric trapping of Rb atoms — •Thomas Rieger, Pepijn Pinkse, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

Here we report on all-electric trapping of Rb atoms. Electric trapping of neutral atoms in time-varying electric fields was already proposed in the early nineties [1]. Recently, Katori and co-workers demonstrated first electric trapping in a micro trap [2]. We have shown two-dimensional trapping (guiding) of neutral molecules in time-varying electric fields [3] with a similar technique. The perspective of sympathetic cooling of molecules with atoms led us to set up an experiment for trapping neutral atoms in time-varying electric fields. In contrast to the one in Ref. [2], our electric trap is of millimeter size, allowing good optical access.

Based on simulations predicting a trap depth of 30 μK, a magneto-optical trap has been setup. The laser-cooled atoms are magnetically trapped and transferred to the electric trap by mechanically moving the trap coils. After turning on the alternating electric fields, the atoms are electrically trapped for a few hundred milliseconds. The experimental results will be discussed in detail.

[1] F. Shimizu and M. Morinaga, Jpn. J. Appl. Phys., **31**, L1721 (1992)
[2] H. Katori et al., AIP Conf. Proc. **770**, 112 (2005)
[3] T. Junglen et al., Phys. Rev. Lett., **92**, 223001 (2004)

A 21.8 Do 15:45 5D

Optical Storage Ring for Cold Atoms — •Andre Lengwenus[1], Jens Kruse[1], Michael Volk[1], Wolfgang Ertmer[2], Matthias Gruber[3], Jürgen Jahns[3], and Gerhard Birkl[1] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, 64289 Darmstadt, Germany — [2]Institut für Quantenoptik, Universität Hannover, 30167 Hannover, Germany — [3]Lehrgebiet Optische Nachrichtentechnik, FernUniversität Hagen, 58084 Hagen, Germany

Most applications for atom interferometers, e.g. sensors for rotation or acceleration, benefit from long interaction times and large enclosed areas. Both can be achieved, using guided interferometer structures for cold atoms. We experimentally demonstrate a new interferometer-type guiding structure for laser cooled neutral atoms based on a ring-shaped dipole potential. The dipole potential is created by focusing a far red-detuned laser beam by a specially designed micro-fabricated optical structure.

We can load atoms into this miniaturized storage ring and can observe how atoms move along the ring-shaped potential minimum. Illuminating only part of the ring lens with a moveable asymmetrical gaussian laser beam gives us the possibility to create a double well potential with variable barrier height. This enables us to move the atoms around the ring as well as dividing and recombining the atom cloud as required for a guided-atom interferometer.

A 22: Poster II - Atomic clusters

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

A 22.1 Do 16:30 Poster B

Erzeugung und Laseranregung mehrfach negativ geladener Aluminiumcluster — Noelle Walsh[1], •Franklin Martinez[1], Falk Ziegler[1], Gerrit Marx[1], Lutz Schweikhard[1] und Josep M. Oliva[2] — [1]Institut für Physik, Ernst-Moritz-Arndt Universität, 17487 Greifswald, Deutschland — [2]Instituto de Química-Física Rocasolano, CSIC, E-28006 Madrid, Spain

Einfach geladene anionische Aluminiumcluster werden in einer Penningfalle einem Elektronenbad ausgesetzt. Dabei nehmen sie weitere Elektronen auf und können zweifach oder dreifach negativ geladen werden. Der Nachweis der Produkte erfolgt durch Flugzeitmassenspektrometrie. Der Transfer in höhere Ladungszustände ist abhängig von der Clustergröße. Insbesondere wird eine gewisse Größe benötigt, um überhaupt stabile Systeme bei höheren Ladungszuständen erzeugen zu können. Die experimentellen Ergebnisse werden mit Abschätzungen aus einfachen Modellansätzen und mit DFT-Rechnungen in der GGA-Näherung (Generalised Gradient Approximation) verglichen.

A 22.2 Do 16:30 Poster B

Interaction of Xe clusters in He nanodroplets with a strong laser pulse — •Alexey Mikaberidze, Ulf Saalmann, and Jan-Michael Rost — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Dynamics of small Xe clusters (∼100 atoms) embedded into medium-sized He droplets (∼1000 atoms) under the action of strong femtosecond (pulse length ∼100 fs) laser pulses is studied microscopically by means of classical molecular dynamics. The results are compared with those for pure Xe clusters.

He droplets are found to enhance considerably inner and outer ionization of Xe clusters. Presumably, transfer of hot electrons from He shell to Xe core and subsequent electron-impact ionization of Xe ions enhance inner ionization of Xe.

Our theoretical studies were stimulated by recent experiments on Xe clusters grown in He droplets and exposed to strong femtosecond laser pulses conducted at Rostock University [1]. Surprisingly high ionic charges at rather low laser intensities ($I \sim 10^{14}$ W/cm^2) were observed in these experiments.

[1] T. Döppner, talk at Atomic Physics 2006, Max Planck Institute for the Physics of Complex Systems, Dresden.

A 22.3 Do 16:30 Poster B

Size-selected cluster deposition as studied by STM — •Chunrong Yin[1], Bernd von Issendorff[1], Stefanie Duffe[2], Thomas Irawan[2], Markus Bieletzki[2], Torsten Richter[2], Benedikt Sieben[2], and Heinz Hövel[2] — [1]Universität Freiburg, FMF, 79104 Freiburg, Germany — [2]Universität Dortmund, Experimentelle Physik I, 44221 Dortmund, Germany

It is very interesting to compare the electronic structure of identical clusters in the free beam and supported on surfaces.

For free clusters the quantized electronic structure as well as the charging in the photoemission process can be studied with photoemission. For clusters at surfaces a topographic investigation with STM was combined with STS and UPS for the study of the electronic structure. Here we will present results for the deposition of mass selected Ag clusters using a cluster machine consisting of a magnetron sputter gas aggregation source, a differential pumping stage with a cryopump and a high transmission infinite range mass selector ($m/\Delta m \geq 50$). The cluster source is combined with a surface-science facility containing a low-temperature STM and high-resolution UPS. With cluster currents of e.g. up to 93 pA for Ag_{55}^+, the deposition time for a reasonable cluster coverage was of the order of 10 minutes. Extremely narrow height distributions ($h/\Delta h \approx 20$) were observed with STM for mass-selected clusters in the size range of Ag_{55}^+ to Ag_{923}^+ deposited with low kinetic energy.

A 22.4 Do 16:30 Poster B

Winkelaufgelöste Photoelektronenspektroskopie an Natrium-Clustern — •Jan Huwer, Christof Bartels, Christian Hock, Raphael Kuhnen, Abdollah Malakzadeh, Jörg Schwöbel und Bernd v.Issendorff — Fakultät für Mathematik und Physik, Universität Freiburg, Stefan-Meier-Straße 19, 79104 Freiburg

Mit einem neu aufgebauten Bildspektrometer wurden Photoelektronenspektren an massenselektierten, kalten Natrium-Clusterionen gemessen.

Es wurden Na_n^--Clusterionen in einem weiten Größenbereich ($n = 2 \ldots 268$) mit ns-Laserpulsen bei den Wellenlängen 308 nm und 500 nm untersucht. Die erhaltenen Energiespektren sind in Übereinstimmung mit den früher gemessenen Spektren ohne Winkelauflösung. Die zusätzlich erhaltenen Winkelverteilungen geben neue Information: Beispielsweise sieht man, dass manche Linien des Energiespektrums aus mehreren Komponenten mit unterschiedlichen Anisotropien zusammengesetzt sind.

Für ausgewählte Größen ($n = 3, 4, 5, 7, 19, 21, 33, 34, 55, 147$) wurden Spektren bei veränderlicher Wellenlänge im Bereich von 290. . . 755 nm in kleinen Schritten aufgenommen. Deren Entwicklung kann für die kleinen Cluster mit einem einfachen Molekülorbital-Modell verglichen werden. Für die größeren Cluster können die β-Parameter aus den Jellium-Potentialen berechnet werden. Ein Vergleich mit den aus den Experimenten extrahierten Werten wird vorgenommen.

A 22.5 Do 16:30 Poster B

Structure and Dynamics of Na Clusters Deposited on Insulator Surfaces — •Matthias Bär[1], Mathias Winkler[2], Lyudmila Moskaleva[2], Paul-Gerhard Reinhard[1], Eric Suraud[3], and Notker Rösch[2] — [1]Institut für Theoretische Physik II, Universität Erlangen-Nürnberg — [2]Institut für Theoretische Chemie, Technische Universität München — [3]Laboratoire de Physique Theorique, Université Paul Sabatier, Toulouse

We study small Na clusters deposited on insulating surfaces like Ar or MgO(001). For this purpose, we employ the time-dependent local-density approximation for the electrons combined with molecular dynamics for the cluster ions (TDLDA-MD). The surface atoms/ions are treated as classical particles interacting with the cluster electrons via local pseudopotentials, while the long range dipole interaction is taken into account through polarization potentials.

In a first exploration, we investigate the influence of the surface on the structure and optical response of small Na clusters. In all cases, we find ground-state configurations which maintain the geometry of the free clusters. Planar isomers which would indicate wetting are energetically disadvantageous.

The optical spectrum is still dominated by the Mie plasmon peaks which are shifted surprisingly little because the two large effects, namely core repulsion the surface atoms/ions (blue shift) and dynamical polarizability of the surface (red shift), almost cancel each other.

In a further step, we discuss the detailed dynamics of cluster deposit on the surface.

A 22.6 Do 16:30 Poster B

Röntgenabsorptionsspektroskopie an freien und deponierten Kobaltclustern — •Vicente Zamudio-Bayer[1], Leif Glaser[2], Jochen Rittmann[1], Marlene Vogel[1], Wilfried Wurth[2], Thomas Möller[1], Bernd von Issendorff[3] und Tobias Lau[1] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, PN 3-1, Hardenbergstraße 36, D-10623 Berlin — [2]Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, D-22761 Hamburg — [3]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg

Die $L_{2,3}$-Röntgenabsorption freier und deponierter Kobaltcluster wurde bei BESSY untersucht. Kleine massenseparierte Kobaltcluster wurden auf der Cu(100)-Oberfläche als schwachwechselwirkende Unterlage deponiert. In den $L_{2,3}$-Röntgenabsorptionsspektren von Monomer, Dimer und Trimer zeigt sich ein Trend, der als Unterdrückung atomarer Linien interpretiert werden kann. Im Vergleich mit freien Kobaltclustern ist der Einsatz der Röntgenabsorption in deponierten Cluster zu höheren Photonenenergien hin verschoben, was auf Abschirmungseffekte durch delokalisierte Valenzelektronen des Substrats hinweist.

Freie Kobaltcluster wurden mittels Ionenausbeutespektroskopie untersucht. Die Relaxation des rumpfniveauangeregten Zustands führt zu höheren Ladungszuständen und anregungsenergieabhängiger Fragmentation der Cluster. Bereits kleine Cluster ($n \approx 50$) zeigen festkörperähnliche Absorptionsspektren.

A 22.7 Do 16:30 Poster B

Röntgenabsorptionsspektroskopie an Übergangsmetall-

Clustern in der Gasphase: Erste Resultate für Titan — •Marlene Vogel[1], Vicente Zamudio-Bayer[1], Jochen Rittmann[1], Thomas Möller[1], Bernd von Issendorff[2] und Tobias Lau[1] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, PN 3-1, Hardenbergstraße 36, D-10623 Berlin — [2]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg

Ein neues Experiment zur Röntgenabsorptionsspektroskopie an freien neutralen Übergangsmetall-Clustern in der Gasphase wird vorgestellt.

Die Cluster werden in einer Magnetron-Sputter-Gasaggregationsquelle erzeugt, durch Synchrotronstrahlung (BESSY) ionisiert und in einem gepulsten, zweistufigen Flugzeitmassenspektrometer massenaufgelöst detektiert. Die Ionenausbeute wird als Funktion der Anregungsenergie im Bereich der $L_{2,3}$-Kanten gemessen, wodurch die Clustergrößenabhängigkeit der resonanten $2p$–$3d$-Anregung untersucht werden kann. Das Verhältnis der Intensitäten von L_2- und L_3-Kanten, die energetische Verschiebung und die Unterstruktur der Kanten bei Titanclustern werden als Funktion der Clustergröße untersucht. Die Fragmentation und der Ladungszustand der Cluster nach der Anregung werden diskutiert. Die spektroskopierten Cluster haben Größenverteilungen von etwas unter 20 bis einige hundert Atome, mit einem Maximum der Verteilung bei ungefähr 50 Atomen.

A 22.8 Do 16:30 Poster B

Wellenlängen- und temperaturabhängige Photoelektronenspektroskopie an C_{60}^- — Christine Wehrstein, Elisabetta Maria Fiordaliso, •Raphael Kuhnen und Bernd von Issendorff — Department of Physics, Universtiy of Freiburg, Stefan-Meier-Strasse 21, 79104 Freiburg

Photoelektronenspektroskopie an C_{60}^- wurde mit ns-Laserpulsen verschiedener Wellenlänge durchgeführt. Die Spektren zeigen zusätzlich zur normalen Emission eine Auger-Emission, bei welcher die Elektronen unabhängig von der eingestrahlten Laserwellenlänge die selbe kinetische Energie beibehalten und welche eine starke vibratorische Verbreiterung aufweist. Dies deutet darauf hin, dass immer der gleiche angeregte Zustand für diesen Auger-Prozess verantwortlich ist.
Bei temperaturabhängiger Photoelektronenspektroskopie tritt eine Verschiebung der Emission aus dem höchsen besetzten molekularen Orbital mit zunehmender Temperatur zu höheren Bindungsenergien auf. Diese lässt sich mit einer erhöhten Anzahl von Vibrationszuständen erklären, die durch die thermisch induzierte Symmetrieerniedrigung des Clusters im angeregten Zustand erreicht werden können.

A 22.9 Do 16:30 Poster B

Optimizing the interaction of silver clusters with intense laser fields — •nguyen xuan truong, tilo döppner, jan müller, andreas przystawik, and karl heinz meiwes-broer — Universität Rostock, Fachbereich Physik, Universitätsplatz 3, 18051 Rostock

Silver clusters are generated by pick-up into helium droplets and exposed to intense fs laser fields. The charging processes of the metal kernel are most efficient when a resonance between the laser frequency and the collective excitation has been established. It has been shown in dual-pulse and focus-scan experiments [1,2] that the dynamics of the process depends on the optical delay and the chosen laser intensity. A self-learning technique is introduced in order to optimize the signal of the highly charged atomic fragments by changing simultaneously the pulse duration, the dual-pulse delay, and the lens position. For 2.5mJ laser pulses the maximum signal of Ag^{+q} (with $q = 14, 16, 17$) is obtained for a delay of 240fs and a lens position of 6mm.
[1] T. Döppner *et al.*, Phys. Rev. Lett. **94**, 013401 (2005).
[2] T. Döppner *et al.*, Eur. Phys. J. D, *submitted*.

A 22.10 Do 16:30 Poster B

Optimal control of the ionization dynamics of the intense fs laser-cluster interaction — nguyen xuan truong, tilo döppner, sebastian göde, •robert irsig, andreas przystawik, josef tiggesbäumker, and karl-heinz meiwes-broer — Universität Rostock, Fachbereich Physik, Universitätsplatz 3, 18051 Rostock

Recent experiments on intense fs laser-cluster interactions have confirmed the dependence of the charging processes on the temporal pulse shape and the laser intensity [1,2]. In this studies we have extended our recent work by modulating both amplitude and phase of the laser pulses in order to optimize the charging process. For this purpose an acousto-optic programmable dispersive filter (Dazzler) is used. The laser pulse resulting from the optimization procedure is fully characterized by frequency-resolved optical gating technique (FROG). First results on metal clusters embedded on helium nanodroplets are presented.

[1] T. Döppner *et al.*, Phys. Rev. Lett. **94**, 013401 (2005).
[2] T. Döppner *et al.*, Eur. Phys. J. D, *submitted*.

A 22.11 Do 16:30 Poster B

Coherent Diffractive Imaging of Atomic Clusters with XFEL Pulses — •Christian Gnodtke, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden, Germany

We study the possibility of coherent diffractive imaging of atomic clusters with intense, femtosecond pulses from X-ray free electron lasers (XFEL). We simulate the diffraction patterns of rare-gas clusters with radii ranging from a few to tens of nanometers in X-ray pulses with laser wavelengths of 32nm, as currently available at FLASH, down to 1Å as will be available from the XFEL at DESY in Hamburg in the future. At large wavelengths intrinsic or induced density inhomogeneities within the cluster on a length-scale comparable to the laser wavelength may become visible in an imaging experiment. Towards shorter wavelengths we approach atomic resolution, which, at a wavelength of 1Å, is limited only by the radiation damage inflicted on the sample by the pulse. We calculate the damage threshold by detailed microscopic simulation of the laser-induced dynamics using quantum-mechanical transition rates combined with a molecular dynamics simulation of the (quasi-)free electrons and ions. Finally, we make use of iterative oversampling algorithms to invert the simulated diffraction patterns to real-space images of the cluster.

A 22.12 Do 16:30 Poster B

Inner Shell Photoelectron Spectroscopy using VUV-FEL Radiation of Mass-Selected Pb-Clusters: A Single Shot Analysis — •Tim Fischer[1], Volkmar Senz[2], Patrice Oelssner[2], John Neville[3], Markus Schöffler[4], Jörg Stanzel[5], Heiko Thomas[6], Matthias Neeb[5], Josef Tiggesbäumker[2], Michael Martins[7], Eckart Rühl[8], Christoph Bostedt[6], Wolfgang Eberhardt[5], Gerd Ganteför[1], Thomas Möller[6], Horst Schmidt-Böcking[4], Reinhard Dörner[4], Wilfried Wurth[7], and Karl-Heinz Meiwes-Broer[2] — [1]Universität Konstanz — [2]Universität Rostock — [3]University of New Brunswick, Canada — [4]Universität Frankfurt am Main — [5]BESSY Berlin — [6]Technische Universität Berlin — [7]Universität Hamburg — [8]Freie Universität Berlin

For clusters the catalytic, chemical and magnetic properties depend strongly on the number of atoms. VUV photoelectron spectroscopy provides a powerfull access to these electronical and geometrical set of problems. Currently, no light source is suitable to measure the entire valence and shallow core levels, except the free-electron-laser FLASH at HASYLAB/DESY. It provides the appropriate radiation of several tens of eV with sufficient high photon flux, but with shot-per-shot fluctuation up to a factor of 10. Furthermore the FEL multibunch structure allows to investigate more than one cluster size per shot.

For measuring the clusters, a resolution and pressure optimised UHV-build up with fast data acquisition were used. Electron time-of-flight data, photon flux and cluster intensity were accumulated for every single shot via ROOT and enables laser intensity related analysis.

A 23: Poster II - Interaction with strong or short laser pulses

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

A 23.1 Do 16:30 Poster B

Noise Embedded Quantum Systems — •Kamal Priya Singh and Jan Michael Rost — Max Planck Institute for the Physics of Complex Systems, Dresden

The effect of noise on the nonlinear photoionization of an atom due to a femtosecond pulse is investigated in the framework of the stochastic Schrödinger equation. A modest amount of white noise results in an enhancement of the net ionization yield by several orders of magnitude, giving rise to a form of quantum stochastic resonance. We demonstrate that this effect is preserved if the white noise is replaced by broadband chaotic light.

A 23.2 Do 16:30 Poster B

Coulomb scattering in strong laser fields — •Sebastian Bauch and Michael Bonitz — Christian-Albrechts-Universität Kiel, Institut für theoretische Physik und Astrophysik, Leibnizstraße 15, 24098 Kiel, Germany

Progress in experiments [1]leads to increasing interest in understanding interaction of atoms with an electromagnetic field in the high intensity regime. Well known effects are the generation of higher harmonics and the above threshold ionization which leads to a generation of high energetic electrons. We solve the multidimensional timedependent Schrödinger equation in the Kramers-Henneberger frame in dipole approximation and present numerical calculations of ionization processes for bound state electrons and electron wave packet scattering processes in strong laser fields for model systems. Recent calculations for electron scattering on a single 1D screened Coulomb potential [2]are extended to multidimensional systems as well as to potential chains. The fast electron spectrum is analyzed.

[1] for a recent overview,see T. Brabec and F. Krausz, Rev. Mod. Phys., Vol. 72, No. 2 (2000)

[2] H.-J. Kull and V.T. Tikhonchuk, Phys. Plas. 12, 063301 (2005)

A 23.3 Do 16:30 Poster B

Asymmetry in the photoelectron angular distribution by two-photon chirped excitation of sodium atoms — •Marc Krug, Matthias Wollenhaupt, and Thomas Baumert — Experimentalphysik III, CINSaT, Fachbereich Physik, Universität Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel

Chirped femtosecond laserpulses generated by spectral phase modulation are used for strong field two-photon excitation and ionization of atomic sodium. Angular resolved photoelectron spectra are measured using a photoelectron imaging spectrometer. Pronounced asymmetries in the photoelectron angular distribution with respect to the sign of the chirp (upchirp/downchirp) are observed experimentally. We present an analysis of the effect based on chirped excitation of a three-level system. Fine details of the excitation/ionization process in sodium are analyzed in terms of numerical calculations on a multi-level system.

A 23.4 Do 16:30 Poster B

Keldysh-Faisal-Reiss theory: analytical and numerical analysis — •Yulian Vanne and Alejandro Saenz — AG Moderne Optik, Institut für Physik, Humboldt-Universität zu Berlin, Hausvogteiplatz 5-7, 10117 Berlin, Germany

Various variations of Keldysh-Faisal-Reiss (KFR) theory (also referred to as the strong-field approximation) are often used nowadays to study the interaction of a strong laser pulse with an atomic or molecular system. Although the general formulation of KFR is known for decades, some issues have not been studied in detail yet. We discuss the validity of the saddle-point approximation and a recently published implementation of the residue theorem to calculate the ionization transition amplitude. Also, a careful analytical and numerical analysis of the quasistatic limit of the velocity-gauge KFR is carried out. Based on the Popov-Peremolov-Terent'ev (PPT) quasistatic formula we derive the Coulomb correction for velocity-gauge KFR.

A 23.5 Do 16:30 Poster B

Laser-driven bound dynamics in multiply charged hydrogen-like ions — •Henrik G. Hetzheim, Guido R. Mocken, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

The interaction of relativistically strong electromagnetic fields with highly charged ions via multiphoton coupling [1,2] gives rise to a large variety of quantum phenomena. Here the laser-ion interaction for resonant multiphoton transitions in hydrogen-like highly charged ions is investigated. In particular the fine structure of the energy levels is taken into account by solving the Dirac equation in 2D numerically. In addition the radiation spectrum of the non-tunneling harmonics [3] is calculated for identifying resonantly driven transitions. The role of relativistic effects is discussed.

[1] C. H. Keitel, Contemporary Physics, **42**, 353–363 (2001).

[2] S. X. Hu and C. H. Keitel, Phys. Rev. A **63**, 053402 (2001).

[3] S. X. Hu, A. F. Starace, W. Becker, W. Sandner and D. B. Milošević, J. Phys. B: At. Mol. Opt. Phys. **35**, 627–650 (2002).

A 23.6 Do 16:30 Poster B

Experimente zur Fragmentation von Atomen und Molekülen in intensiven phasenstabilisierten 6 fs Laserpulsen — •Manuel Kremer, Oliver Herrwerth, Hartmut Gimpel, Thorsten Ergler, Artem Rudenko, Karl Zrost, Bernold Feuerstein, Claus Dieter Schröter, Robert Moshammer und Joachim Ullrich — Max-Planck-Institut für Kernphysik, Heidelberg

Die Verwendung von sehr kurzen (6 fs) Laserpulsen mit einer stabilisierten Phase zwischen der Trägerwelle und der Einhüllenden des Pulses (die sogen. CEO-Phase) erlaubt eine Vielzahl neuartiger Untersuchungen zum Verhalten von Atomen und Molekülen in intensiven Laserfeldern. Jüngste Experimente haben gezeigt, dass es möglich ist Effekte, die vom zeitlichen Verlauf des elektrischen Feldes abhängen, mit einer Genauigkeit von einigen 100 Attosekunden aufzulösen. Damit erreicht man erstmals Zeitskalen, die um ein Vielfaches kürzer sind als die schnellsten rovibronischen Oszillationen in Molekülen und damit fast vergleichbar sind mit der klassischen Umlaufzeit äußerer Elektronen in Atomen und Molekülen. In Kombination mit einem Reaktionsmikroskop, mit dem die Impulsvektoren aller auslaufenden Teilchen vermessen werden, konnten erste Experimente zur Bestimmung der absoluten CEO-Phase mittels phasenabhängiger Reaktionen bei der Wechselwirkung von 6 fs Lichtpulsen mit leichten Edelgas-Atomen durchgeführt werden. In geplanten Pump-Probe-Experimenten zur Fragmentation von H2 soll das Verhalten der Elektronen sowohl im Pump- als auch im Probepuls zeitaufgelöst untersucht werden. Das aufgebaute Lasersystem sowie weitere experimentelle Möglichkeiten werden vorgestellt.

A 23.7 Do 16:30 Poster B

Time-resolved studies of CH4 fragmentation in intense laser fields — •Ulrich Wiedemann[1], Artem Rudenko[1], Thorsten Ergler[1], Karl Zrost[1], Bernold Feuerstein[1,2], Claus Dieter Schröter[1], Robert Moshammer[1], and Joachim Ullrich[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Physikalisches Institut, Universität Heidelberg, 69120 Heidelberg

The break-up of methane molecules exposed to intense laser fields has been studied using a combination of a 'Reaction Microscope' spectrometer and a femtosecond pump-probe setup. The time evolution of a particular fragmentation reaction (e.g., one- or few-electron dissociative ionization) induced by the 'pump' pulse (9 fs, 4x10^14 W/cm^2, central wavelength 780 nm) was probed with the identical 'probe' pulse arriving after a variable time delay. Using 3D Coulomb explosion imaging we were able to visualize the dissociation dynamics of the singly ionized methane molecule, and found that it strongly depends on the final localization of the charge, which is reflected in very different fragment angular distributions for the two reaction pathways (CH4+ => CH3 + H+ and CH4+ => CH3+ + H). Exploiting this dependence for the channel separation, we map the ionization probability for both pathways as a function of the delay, and, thus, of the internuclear distance. Moreover, similar to earlier results on the CH4 fragmentation by ion impact or VUV radiation, we observe that double ionization often leads to the formation of a hydrogen molecular ion. Possible mechanisms of this bond-forming reaction as well as the relevant time scales estimated from the experimental data will be discussed.

A 23.8 Do 16:30 Poster B

Imaging of clusters by femtosecond scattering of intense soft X-rays — •Ekaterina Eremina[1], Christoph Bostedt[1], Matthias Hoener[1], Heiko Thomas[1], Thomas Möller[1], Tim Laarman[2], Hu-

BERTUS WABNITZ[3], and ANTONIO RUBENS BRITTO DE CASTRO[4] — [1]Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Max-Born-Institut, Max-Born-Straße 2A, 12489 Berlin, Germany — [3]DESY, Notkestr. 85, 22603 Hamburg, Germany — [4]LNLS, IFGW UNICAMP,Campinas SP Brazil

Imaging of non-periodic structures, such as macromolecules and nanoparticles is one of the most attractive perspectives for the upcoming X-ray FELs [1,2]. We present the first results on imaging of rare gas clusters by means of scattering of 32nm and 13.6 nm photons from the FLASH (Free-Electron-Laser at DESY, Hamburg). Single shot diffraction patterns could be recorded before the radiation damage on clusters took place during an intense (10^{14} - 10^{15} W/cm^2) 25 fs pulse. A novel MCP-based imaging detector system was developed for these experiments [3]. Model calculations for spherical clusters based on Mie-scattering theory agree well with the experimental data. The results provide a basis for future two-color pump-probe experiments, which allow time-resolved investigations of fragmentation and explosion dynamics of clusters exposed to intense x-rays.

[1] R. Neutze et al., Nature 406, 752 (2000)
[2] H.N. Chapman et al., Nature Phys. 2, 839 (2006)
[3] E. Eremina et al., DESY report (2006)

A 23.9 Do 16:30 Poster B

Interaction of HeH^{2+} quasimolecule with short intense laser pulses — •LUIS FERNANDEZ-MENCHERO[1], HANS JÜRGEN LÜDDE[2], and TOM KIRCHNER[1] — [1]Institut für Theoretische Physik, TU Clausthal, Leibnizstraße 10, 38678 Clausthal-Zellerfeld — [2]Institut für Theoretische Physik, Universität Frankfurt, Max-von-Laue-Straße 1. 60438 Frankfurt

In our work we apply the Basis Generator Method (BGM) [1] to the interaction between a diatomic molecule and a short laser pulse ($\sim$ fs.). The Two Center-BGM is practical to calculate the electron dynamics with a relatively small set of functions to describe the ionization continuum. Due to the building of the basis set the coupling between the subspace $\mathcal{A}$ of Hilbert space, which is described in terms of our finite basis set, and its infinite complement $\mathcal{B}$ is minimized.

In the present work we study the ionization and molecular excitation processes in the asymmetric quasimolecule HeH^{2+} when it interacts with a short intense laser pulse. This system was previously studied in [2], which is a good reference to test the method.

[1] Lüdde et al, J. Phys. B. **29**, 4423 (1996)
[2] Lagmago Kamta and Bandrauk Phys. Rev. Let. **94**, 203003 (2005)

A 23.10 Do 16:30 Poster B

Molecular Hydrogen in strong linearly polarized laser fields — •TIMO WILBOIS, WOLFGANG KAMKE, and HANSPETER HELM — Department of Molecular and Optical Physics, Stefan-Meier-Str. 19, 79104 Freiburg, Germany

In strong field experiments with molecular hydrogen at a wavelength of 326 nm resonance peaks appear at electron energies corresponding to release energies in resonant ionization of atomic hydrogen via Rydberg states [1][2]. This behaviour of H_2 in strong fields was now investigated at wavelengths around 800 nm with 100 fs pulses.

In this work photoelectrons were observed in an imaging spectrometer. The 3D angular resolved momentum distribution of the electrons was reconstructed from the measured 2D-distribution using a backinversion algorithm. We identified resonance peaks in the energy spectra where Rydberg resonances in atomic hydrogen are expected. Thus the simplification of H_2 spectra for multi-photon ionization at 800 nm was verified for the principal quantum number n$\geq$ 4. Additional resonances below the n=4-energy are assigned to resonant ionization via vibrational levels of the B $^1\Sigma_u^+$ state. We compare our results with a model calculation and a first theoretical study on this issue [3].

[1] H. Helm, M. Dyer, H. Bissantz: PRL 67, 1234 (1991).
[2] H. Rottke, B. Wolff-Rottke, D. Feldmann, and K. H. Welge, M. Dörr, R. M. Potvliege, R. Shakeshaft: PRA 49, 4837 (1994).
[3] H. Kono, M. Kanno, T. Kato, Y. Fujimura, and F. H. M. Faisal: LPHYS 05, Kyoto Book of Abstracts (2005), 138 and Private comm. with H. Kono and M. Kanno, Tohoku University Sendai, Japan.

A 23.11 Do 16:30 Poster B

Einfluss der Magnetfeldkomponente auf die e^-e^+-Paarbildung in starken, gegenläufigen Laserfeldern — •MATTHIAS RUF, GUIDO R. MOCKEN, CARSTEN MÜLLER, KAREN Z. HATSAGORTSYAN und CHRISTOPH H. KEITEL — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Bei der theoretischen Untersuchung von Elektron-Positron-Paarbildung in gegenläufigen, hochintensiven Laserfeldern wurden diese bislang immer durch oszillierende elektrische Felder beschrieben [1,2]. In dieser Arbeit wird Paarbildung durch numerische Propagation eines Dirac-Elektrons mithilfe eines auf dem Split-Operator-Verfahren basierenden Codes [3] untersucht. Solch ein Ansatz ermöglicht zum ersten Mal, den Einfluss des magnetischen Feldes mit zu berücksichtigen. Es zeigt sich, dass das Magnetfeld die Erzeugungsrate für hohe Laserfrequenzen deutlich verringert und die resonante Signatur des Prozesses verändert [2].

[1] H. K. Avetissian et al., Phys. Rev. E 66, 016502 (2002)
[2] K. Z. Hatsagortsyan, G. R. Mocken, M. Ruf, C. Müller und C. H. Keitel: in Vorbereitung
[3] G. R. Mocken und C. H. Keitel, J. Comp. Phys. 199, 558 (2004)

A 23.12 Do 16:30 Poster B

Erhöhung des Elektronentransfers in laserassistierten p-Ne und p-Ar Stößen — •TOM KIRCHNER — Institut für Theoretische Physik, TU Clausthal, Leibnizstraße 10, 38678 Clausthal-Zellerfeld

Ion-Atom-Stöße in der Gegenwart starker Laserfelder wurden in jüngster Zeit in verschiedenen Aspekten und mittels unterschiedlicher Methoden theoretisch untersucht (s. z.B. [1]). Eine Reihe interessanter Effekte wurde vorhergesagt, die allerdings den Schönheitsfehler haben, dass sie sich nicht unmittelbar experimentell überprüfen lassen: entweder wurde von schwer zu realisierenden Laserfeldern ausgegangen, oder es wurden atomare Wasserstofftargets betrachtet, die für die ohnehin als sehr anspruchsvoll einzuschätzenden Experimente ungeeignet sind.

Um laserassistierte Streuexperimente dennoch anzubahnen, ist es wichtig, konkrete theoretische Voraussagen über observable Effekte unter realistischen Bedingungen bereitzustellen. Basierend auf den Konzepten der zeitabhängigen Dichtefunktionaltheorie werden in diesem Beitrag langsame p-Ne und p-Ar Stöße untersucht. Die Resultate für Elektronentransfer legen nahe, dass das zweite System ein lohnender Kandidat für experimentelle Arbeiten ist: unterhalb von 1 keV Projektilenergie wird der totale Wirkungsquerschnitt schon bei moderaten Feldstärken eines 800 oder 1064 nm Lasers signifikant erhöht. In p-Ne Stößen ist entweder ein intensiveres oder ein kurzwelligeres Feld nötig, um einen merklichen Effekt zu erzielen. Beide Ergebnisse lassen sich anhand von molekularen Potentialkurven qualitativ verstehen.

[1] F. Anis *et al.*, Phys. Rev. A **73**, 043414 (2006)

A 23.13 Do 16:30 Poster B

Ionization of an atom in a strong laser pulse: numerical integration versus strong field theories. — •YULIAN VANNE and ALEJANDRO SAENZ — AG Moderne Optik, Institut für Physik, Humboldt-Universität zu Berlin, Hausvogteiplatz 5-7, 10117 Berlin, Germany

A systematic study of the ionization process of an atom in a strong laser pulse has been performed by means of both a full numerical integration of the Schrödinger equation and various variations of Keldysh-Faisal-Reiss (KFR) theory (also referred to as strong-field approximation). Key features of the photoelecton spectra and the total ionization yield are discussed for different peak intensities, pulse lengths and frequencies. All calculations are carried out for Gaussian-shaped pulses to avoid possible unphysical results. In the quasistatic limit we compare to the predictions of tunneling theories.

A 23.14 Do 16:30 Poster B

A Lithium-MOT Target in a Reaction Microscope — JOCHEN STEINMANN, GANJUN ZHU, •ALEXANDER DORN, and JOACHIM ULLRICH — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

In order to perform kinematically complete experiments on single, double and triple ionization of lithium induced, e.g., by electron impact or intense laser pulses we have combined for the first time a reaction microscope (combined recoil-ion and electron momentum spectrometer) with a magneto-optical trap target (MOT). A cloud of 1 mm diameter with 10 million lithium atoms cooled down well below 1 mK temperature constitutes an ideal target for high resolution momentum spectroscopy. However, a high resolution momentum measurement of ions and in particular electrons requires a pulsed mode operation of the atomic trap magnetic field.

We have successfully commissioned the apparatus and first measurements were performed for single ionization of ground state and laser excited lithium in strong near infrared fs-laser pulses.

A 23.15 Do 16:30 Poster B

Investigation of x-ray and high energy ions produced by laser-

generated plasma in H2- and He-droplets — Rui Alexandre Costa Fraga and •Nikos Petridis — IKF JWG - Universität Frankfurt

siehe Titel

A 23.16 Do 16:30 Poster B

Ionization of helium by 5.9fs elliptical laser pulses — •Mathias Smolarski[1], André Staudte[2], Markus Schöffler[1], Ottmar Jagutzki[1], Reinhard Dörner[1], Petrissa Eckle[3], Philip Schlup[3], Jens Biegert[4], and Ursula Keller[3] — [1]Institut für Kernphysik, Johann Wolfgang Goethe Universität, Max-Von-Laue-Str. 1, 60438 Frankurt am Main, Germany — [2]Steacie Institute for Molecular Sciences, National Research Council of Canada, 100 Sussex Drive Ottawa, ON K1A 0R6 Canada — [3]Department Physik, ETH Zurich, Wolfgang-Pauli-Str. 16, 8093-Zurich, Switzerland — [4]ICFO - Institut de Ciències Fotòniques, Parc Mediterrani de la Tecnologia, Av. del Canal Olímpic s/n, 08860 Castelldefels, (Barcelona), Spain

The present work presents the momentum distribution of helium ions, created in the single ionization of helium by a 5.9 fs, CEO phase stabilized laser pulse with a small ellipticity. The difference from the expected momentum distribution created by circular light is explained using the ADK theory and classical propagation of the particles in the electric field of the laser.

A 24: Poster II - Interaction with VUV and X-ray light

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

A 24.1 Do 16:30 Poster B

Direct interaction of light with quantum systems governed by the strong force — •Andreas Ipp[1], Adriana Pálffy[1], Thomas J. Bürvenich[2], Jörg Evers[1], and Christoph H. Keitel[1] — [1]Max Planck Institute for Nuclear Physics, Heidelberg — [2]Frankfurt Institute for Advanced Studies

The direct interaction of atoms and laser fields allows in many cases for a controlled preparation, manipulation, and measurement of the internal and external degrees of freedom of the atoms, giving rise to a multitude of applications [1]. A key ingredient to many of these schemes is the coherence of the light field, and therefore, it is not surprising that present and upcoming light sources aim at extending the availability of coherent light both towards higher frequencies and intensities. Thus the question arises whether light-matter interaction, reminiscent of quantum optics, is also possible in quantum systems characterized by much higher energy scales. For example, recently it was shown that super-intense laser fields make the direct interaction of laser and nuclei feasible [2]. Here, we discuss prospects of controlled matter-light interaction in quantum systems governed by the strong interaction. Our model systems include quark-gluon plasmas and highly excited nuclei.

[1] M. O. Scully and M. S. Zubairy, Quantum optics (Cambridge, 1997).

[2] T. J. Bürvenich, J. Evers, and C. H. Keitel, Phys. Rev. Lett. 96, 142501 (2006).

A 24.2 Do 16:30 Poster B

Quantum dynamics in atomic and molecular fragmentation by strong FLASH pulses — •Y. H. Jiang[1], R. Moshammer[1], L. Foucar[2], A. Rudenko[1], Th. Ergler[1], C.D. Schröter[1], S. Lüdemann[1], K. Zrost[1], D. Fischer[3], J. Tietze[2], T. Jahnke[2], M. Schöffler[2], T. Weber[2,4], R. Dörner[2], T. Zouros[5], A. Dorn[1], T. Ferger[1], K.U. Kühnel[1], J. Ullrich[1], R. Treusch[4], P. Radcliff[4], and E. Plönjes[4] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Institut für Kernphysik, Universität Frankfurt, D 60486 Frankfurt — [3]Stockholm University, Stockholm — [4]DESY, Notkestrasse 85, 22607 Hamburg — [5]University of Crete, Greece

Few-photon multiple ionization of Ne and Ar atoms as well as D_2 molecule by strong VUV laser pulses from the Free electron LASer at Hamburg (FLASH) was investigated differentially with the reaction microscope. The light of wavelengths 44 nm and 32 nm, a pulse duration of ≈50 fs, at pulse energies ≈3-10 μJ, allows to observe few-photon multiple ionization of atoms and molecules The light intensity dependence of ion production yields reveals the dominance of non-sequential multi-photon ionization mechanisms at relative low intensities. Recoil ion momentum spectroscopy of Ne^{2+} shows for the first time that two electrons absorbing "instantaneously"two photons are ejected mostlikely into opposite hemispheres with very similar energies, a situation that is strongly different in single photon double ionization or even forbidden for equal energies in strictly opposite direction.

A 24.3 Do 16:30 Poster B

The Variable Polarization XUV Beamline at PETRA III — •Jens Viefhaus and Frank Scholz — DESY, Hamburg, Garmany

The storage ring PETRA III (DESY, Hamburg) with its very low emittance of 1 nm rad makes it an excellent facility to host a Variable Polarization XUV Beamline. User operation of the beamline will start in 2009 right after the startup phase of PETRA III.

The high brilliance and flux of the beamline provided in a broad photon energy range (200 eV to 3000 eV) will open up new scientific opportunities in fields like high resolution PES, spectroscopy of dilute targets, emvironmental chemistry and many more.

Key absorption edges of practically all important elements lie in the range of photon energies provided by the beamline which creates the possibility to uniquely determine the element-specific local electronic structures. Of equal importance will be polarization-dependent studies using the 5 m APPLE-II-type undulator (65.6 mm period) which allows full polarization control by the user and operates over the whole photon energy range in the first harmonic providing both high flux and complete polarization. Using state-of-the-art technology it is possible to achieve a spectral resolving power of more than 10000 with an extremely high flux ($\geq 10^{12}$ photons/sec) inside a focal spot of the order of 10 μm. Together with the main source parameters a detailed layout of the beamline will be presented.

A 24.4 Do 16:30 Poster B

Hochauflösende Röntgenabsorptions- und Röntgenemissionsmessungen an Titanverbindungen — •Falk Reinhardt[1,2], Burkhard Beckhoff[1], Birgit Kanngiesser[2], Matthias Müller[1], Beatrix Pollakowski[1] und Gerhard Ulm[1] — [1]Physikalisch-Technische Bundesanstalt, Abbestr. 2-12, 10587 Berlin — [2]Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin

Der Vergleich zwischen hochauflösender Röntgenemissionsspektroskopie und NEXAFS (Near-Edge X-ray Absorption Fine Structure) Spektroskopie mit durchstimmbarer Synchrotronstrahlung an den L(ii,iii)-Kanten von Titan wird gezeigt. Beide Methoden ermöglichen die zerstörungsfreie chemische Speziation von Elementen in ihren Verbindungen. Dazu wird die Struktur und Lage der Absorptionskanten untersucht und mit den sich ändernden Lagen und Übergangswahrscheinlichkeiten der Emissionslinien in Beziehung gesetzt. Die Messungen fanden am Plangittermonochromator - Strahlrohr der PTB für Undulatorstrahlung bei BESSY II statt. Die Röntgenemission wurde mit einem wellenlängendispersiven Spektrometer basierend auf einem sphärischen Gitter und einer CCD untersucht. Für die Absorption wurde die Fluoreszenzstrahlung mit einem Si(Li)-Detektor gemessen.

A 24.5 Do 16:30 Poster B

Electron dynamics in clusters excited by strong short-wavelength laser fields — •Ionuţ Georgescu, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzerstr. 38, 01187 Dresden, Germany

Shining a strong short-wavelength laser pulse on rare gas clusters results into dense, warm plasmas which absorb energy very effectively by means of inverse bremsstrahlung. Due to the small quiver energy (in contrast to IR pulses) and to the small kinetic energy of the photoelectrons (in contrast to X-Ray pulses), these systems show unique features such as inner-ionization, charge localization and shift of the atomic levels due to screening.

We discuss the theoretical description of these processes, which turn out to depend critically on the treatment of the inner ionization process as well as on the electron-ion interaction potential.

Furthermore, we present our results which are in very good agreement with the initial experiments at 98nm and the most recent ones at 32nm wavelength, both performed at the free electron laser facility at DESY, Hamburg. Finally, we propose a pump-probe scheme with atto-second XUV pulses to gain further, time resolved insight into the energy absorption process.

A 25: Poster II - Photoionization

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

A 25.1 Do 16:30 Poster B

Entanglement in atomic photoionization and decay processes — •Thomas Radtke[1], Stephan Fritzsche[1], and Andrey Surzhykov[2] — [1]Institut für Physik, Universität Kassel, D-34132 Kassel, Germany — [2]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany

Atomic photoionization and decay processes have been studied intensively during the last decades. Recently, however, the interest in these processes was renewed in the context of quantum information processing as they may enable one to observe and manipulate entanglement. Therefore, in order to explore the role of entanglement in the photoionization of alkaline-earth metals, we have studied the photoion-electron entanglement as function of the photon angle and energy. It was found that the photoion-electron entanglement decreases significantly near the ionization threshold and that, in general, it depends on both the photon energy and angle [1].

Another atomic process of interest is the two-photon decay of the metastable 2S state of hydrogen or hydrogenlike systems. For this decay, it was verified by Perrie and coworkers that the outcome of polarization measurements on the emitted photons violate Bell's inequality so that the photons are polarization entangled [2]. Using the density-matrix theory, we have analyzed the photon-photon entanglement in dependence on the emission angles of the two photons and the polarization of the initial 2S states.

[1] T. Radtke, S. Fritzsche, A. Surzhykov, PRA 74, 032709 (2006).
[2] W. Perrie et al., PRL 54, 1790 (1985).

A 25.2 Do 16:30 Poster B

Observation of the interaction between Rydberg series of doubly excited states in Kr and Xe after excitation with narrow bandwidth synchrotron radiation by photon induced fluorescence spectroscopy (PIFS) — •Stephan Klumpp[1], Witowslaw Kielich[1], Lutz Werner[1], Arno Ehresmann[1], Viktor Sukhorukov[2], Ivan Petrov[2], and Philip Demekhin[2] — [1]Institut für Physik und CINSaT , Universität Kassel — [2]Rostov State University of Transport Communications

Xe gas was excited with synchrotron radiation of narrow bandwidth produced by the undulator U125/2 of BESSY II, Berlin, and dispersed by a 10m NIM. The emitted and dispersed Xe fluorescence lines were observed simultaneously within a fluorescence wavelength range between 90nm and 100nm using the method of PIFS. In the exciting-photon energy range between 25.25eV and 25.50eV Codling and Madden 1972 and Wills et. al. 1990 published a number of resonances but weren't able to assign quantum numbers. With the narrow bandwidth excitation radiation it was possible to resolve a more detailed spectrum of the named excitation-photon energy range. According to Codling and Madden the visible resonance features measured in this exciting-photon energy region are due to correlative doubly excited states in XeI. Calculations for doubly excited states in KrI will be presented taking into account core relaxation and interaction between many resonances and many continua explaining Rydberg series $5snp\,^4P_{1/2}$ and $5snp\,^2P_{3/2}$ of doubly excited states in KrI in the fluorescence emission spectra of KrII.

A 25.3 Do 16:30 Poster B

Readout of Delayline Detectors using Transient Recorder Technique — •Lutz Foucar[1], Achim Czasch[1,2], Ottmar Jagutzki[1,2], Sven Schössler[1], Till Jahnke[1], Horst Schmidt-Böcking[1,2], and Reinhard Dörner[1] — [1]Johann Wolfgang Goethe-Universität Frankfurt am Main, Institut für Kernphysik — [2]RoentDek GmbH, Im Vogelshaag 8, Kelkheim

In order to study high correlated systems, it is necessary to detect and measure the position of all participating fragments with high precision. To detect the position of the impact a Delayline Anode is used. Usually the readout of the Delayline Anode is done via a Constant Fraction Discriminator. We are studiing the advanced of using a Transient Recorder Readout of Delayline Anode Detektors over Constant Fraction Discriminators. Using the Transient Recorder Readout Technique, one is able to detect many particles with a very small deadtime. In this Presentation we compare the two techniques on exemplary experiments.

A 25.4 Do 16:30 Poster B

Symmetrie und deren Brechung im H_2^+ Molekül — •Tilo Havermeier[1], Lutz Foucar[1], Thorsten Weber[1], Katharina Kreidi[1], Markus Schöffler[1], Lothar Schmidt[1], Till Jahnke[1], Fernando Martín[3], Jorge Fernández[3], Allen Landers[4], Ottmar Jagutzki[1], Achim Czasch[1], Emanuel Benis[5], Timur Osipov[2], Ali Belkacem[2], Mike Prior[2], Horst Schmidt-Böcking[1], Charles Lewis Cocke[5] und Reinhard Dörner[1] — [1]Institut für Kernphysik, University Frankfurt, Max von Laue Str 1, D-60438 Frankfurt, Germany — [2]Lawrence Berkeley National Lab., Berkeley CA 94720 — [3]Departamento de Química, C-9, Universidad Autónoma de Madrid, 28049-Madrid, Spain — [4]Department of Physics, Auburn University Auburn AL-36849 — [5]Department of Physics, Kansas State University, Cardwell Hall, Manhattan KS 66506

Die Ununterscheidbarkeit der zwei Protonen im dissoziierenden H_2^+ Molekül lässt es nicht zu, dass das Elektron bei der Bildung des neutralen Wasserstoff-Atoms einen beiden Kerne bevorzugt. Hier wird jedoch ein Weg aufgezeigt, wie über die Besetzung doppelt angeregter Zustände diese Symmetrie gebrochen werden kann. Es wurde im März 2005 ein Experiment an der Advanced-Light-Source in Berkeley durchgeführt, bei dem durch Photoionisation die dissoziierenden Zerfallskanäle von Wasserstoff- und Deuterium-Molekülen untersucht wurden. Mit Hilfe der COLTRIMS-Methode wurden die Impulse der entstehenden Photo-Fragmente vermessen, wodurch eine Übersicht aller auftretenden Zustände erstellt werden konnte.

A 26: Poster II -Attosecond physics

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

A 26.1 Do 16:30 Poster B

Hydrogen and helium exposed to an attosecond electric field pulse — •Ulrich Kleiman and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, D-01187 Dresden, Germany

The characteristics of excitation and ionization of atoms exposed to very short electric field pulses are different from what is known from the long pulse and continuous wave regimes.

We investigate the effect of a linearly polarized short electric field pulse of 1–5 cycles applied to hydrogen and collinear helium quantum mechanically by solving the time-dependent Schrödinger equation by means of the split-operator fast Fourier transform method [1]. After a few modifications [2], one can handle the singularities of the Coulomb potential and the electron-electron interaction term. Stimulated by a recent theoretical study of the hydrogen ground state based on the discrete variable representation [3], we shall check whether or not the initial states of hydrogen and, more interesting, collinear helium can be fully restored by using two alternating linearly polarized one-cycle

pulses.

[1] M.D. Feit et al., J. Comput. Phys. 47, 412 (1982).
[2] M.R. Hermann and J.A. Fleck Jr., Phys. Rev. A 38, 6000 (1988).
[3] D. Dimitrovski et al., Phys. Rev. Lett. 93, 083003 (2004).

A 26.2 Do 16:30 Poster B

Ground state correlation and dynamical processes in fast ion-helium-collisions — •Markus Schöffler[1], Jasmin Titze[1], Lothar Schmidt[1], Colm Whelan[2], Alexander Godunov[2], James Walters[3], Ottmar Jagutzki[1], Horst Schmidt-Böcking[1], and Reinhard Dörner[1] — [1]Johann Wolfgang Goethe-Universität, Frankfurt, Germany — [2]Old Dominion University, Norfolk, USA — [3]The Queens University of Belfast, Belfast, UK

Correlated many-particle dynamics in Coulombic systems, which is one of the unsolved fundamental problems in AMO-physics, can now be approached experimentally with so far unprecedented completeness and precision. The recent development of the COLTRIMS technique (COLd Target Recoil Ion Momentum Spectroscopy) provides a coincident multi-fragment imaging technique for quasi snapshots of the correlated dynamics between electrons and nuclei. Recent transfer ionization studies of fast ion-He collisions will be presented and the direct observation of bound correlated electron pairs will be discussed. We could distinguish between different ionization mechanisms and reveal the tiny non-sˆ2 contributions from helium groundstate.

A 26.3 Do 16:30 Poster B

Dissociative double capture in 15N7+ and H2 collisions — •Nadine Neumann, Dorota Hant, Lothar Schmidt, Markus Schöffler, Jasmin Titze, Ottmar Jagutzki, and Reinhard Dörner — Institut für Kernphysik, J.W. Goethe Universität, Max-von-Laue-Str. 1, 60438 Frankfurt

Because of the high potential energy (up to 30 keV/u) and the low velocity of the ions from the ECR-Source, the main reaction channel in collisions with atoms or molecules is electron capture. The experimental set up will be designed for single capture and double capture with coulomb explosion in molecules, especially for the following reactions:

15N7+ + H2 -> 15N5+ + H+ + H+

The highly charged projectile passes the target molecule in a random distance where Rutherford- and atomic scattering are possible reactions. When the projectile scatters on an electron or the core of the molecule it can be detected out of the center of the beam with a time- and position sensitive MCP-Detector with delay-line anode. The deflection angle of the projectile is a parameter how close the projectile passes the target molecule. The knowledge of this impact parameter is one big advantage of ion-atom and ion-molecule experiments compared to photon-atom or photon-molecule interactions.

A 26.4 Do 16:30 Poster B

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

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

A 27: Ultracold collisions (jointly with Q)

Zeit: Freitag 10:30–12:30 Raum: 6G

Hauptvortrag A 27.1 Fr 10:30 6G

Quantum effects in collisions of ultracold atoms with walls and nanostructures — •Javier Madroñero, Florian Arnecke, Alexander Jurisch, and Harald Friedrich — Physik Department, Technische Universität München, München

Collisions of ultracold atoms with walls and nanostructures are, at sufficiently low energy, dominantly influenced by quantum effects, e.g. quantum reflection in the nonclassical region of an attractive atom-surface potential and dominance of low partial waves in the elastic scattering by nanospheres. We discuss possibilities of exploiting such effects to probe atom-surface potentials or to trap atoms without the help of auxiliary fields.

A 27.2 Fr 11:00 6G

Ellastic collisions in a mixture of Yb and Rb atoms — Sven Kroboth, •Nils Nemitz, Florian Baumer, Claudia Höhl, and Axel Görlitz — Institut für Experimentalphysik, Universität Düsseldorf

The collisional properties of atoms play an important role in determining the features and realizability of quantum gases.

We report on an experimental study of inter-species collisions in a mixture of cold ytterbium and rubidium atoms. The Yb atoms are held in a bichromatic optical dipole trap designed to have minimal effect on the evaporatively cooled ^{87}Rb atoms which are held in a Ioffe-Pritchard type magnetic trap.

Collisions are observed through sympathetic cooling of Yb by Rb. In our experiment, the Yb temperature decreases from initially 50μK to near the Rb temperature of 20μK on a time scale of a second for the isotopes ^{174}Yb and ^{176}Yb. In contrast, a much smaller thermalization rate found for ^{172}Yb indicates a significantly smaller cross-section for collisions with Rb.

Our results are an important step towards the creation of a mixed quantum gas and heteronuclear Yb-Rb molecules.

A 27.3 Fr 11:15 6G

Wechselwirkungen ultrakalter Li-Rb-Gemische — •Carsten Marzok, Benjamin Deh, Philippe W. Courteille und Claus Zimmermann — Physikalisches Insitut, Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen

Gemische ultrakalter Gase erleben in den letzten Jahren rasant wachsendes Interesse. BEC–BCS–Übergänge sowie reichhaltige Phasendiagramme in optischen Gittern im Falle von Fermi–Bose–Gemischen ebenso wie Wechselwirkungen in Doppel–BECs im Falle von Bose–Bose–Gemischen sind Beispiele für das breite Spektrum an beobachtbaren Effekten. Dem System Li–Rb kommt mit seinem großen Massenunterschied eine besondere Rolle zu, da man sich dem Gültigkeitsbereich der Born–Oppenheimer–Näherung annähert. Das ^{6}Li–^{87}Rb Fermi–Bose–Gemisch kann damit in einem optischen Gitter prinzipiell als Modellsystem eines Festkörpers verwendet werden. Repulsive Wechselwirkungen im Bose–Bose–Gemisch ^{7}Li und ^{87}Rb hingegen könnten das instabile ^{7}Li BEC im Hyperfeinzustand $|F, m_F\rangle = |2, 2\rangle$ stabilisieren. Um diese Effekte zu studieren, benötigt man Informationen und Kontrolle über die gegenseitigen Wechselwirkungen, ausgedrückt in der s–Wellen–Streulänge. Magnetische heteronukleare Feshbachresonanzen können hier sowohl als Bestimmungsgröße als auch als wertvolles Werkzeug dienen. Beide $^{(6/7)}$Li–^{87}Rb Gemische konnten wir durch sympathetisches Kühlen zu ultrakalten Temperaturen bringen und heteronukleare Wechselwirkungsparameter bestimmen.

A 27.4 Fr 11:30 6G

Magnetic noise in atom chips: impact of finite wire size — •Bo Zhang and Carsten Henkel — Institute fuer Physik, Universitaet Potsdam,Germany

We provide a detailed analysis of spin-flip transitions in atom chips, taking into account complex geometries. We focus on metallic wires of different shapes and cross-sections deposited on dielectric substrates. Our results show that the finite thickness and width of a metallic wire have an obvious impact on the atom trap lifetime. The spin orientation makes a big difference for magnetic noise above finite wires, in striking contrast to infinitely extended planar structures. Different interpolation formulas and approximations for magnetic field fluctuations in the near field of the wire are compared to exact numerical calculations. We work with surface integral equations and the boundary element method. Comparing to the surface impedance approximation familiar

from microwave engineering, we find significant differences when the distance between the atom and the metallic surface is smaller than the skin depth.

A 27.5 Fr 11:45 6G

Interacting Rubidium and Caesium Atoms — •Claudia Weber, Michael Haas, Shincy John, Vanessa Leung, Lars Steffens, Daniel Frese, Dietmar Haubrich, Arno Rauschenbeutel, and Dieter Meschede — Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, 53115 Bonn

In our experimental set up we simultaneously store Rubidium and Caesium in a magnetic trap. We use species-selective microwave cooling on the Rubidium groundstate hyperfine transition. Caesium is sympathetically cooled via elastic collisions with Rubidium. We are thus able to cool down the mixture to temperatures below 1 μK. Below 4 μK we observe strong losses of Caesium.
Analysing the dynamics of sympathetic cooling we are able to estimate a lower limit for the Rubidium-Caesium s-wave scattering length.

A 27.6 Fr 12:00 6G

Interactions of metastable neon atoms in magnetic and optical traps — •N. Herschbach[1], W.J. van Drunen[1], W. Ertmer[2], and G. Birkl[1] — [1]Institut für Angewandte Physik; Technische Universität Darmstadt, Schlossgartenstr. 7, D-64289 Darmstadt, Germany — [2]Institut für Quantenoptik; Leibniz Universität Hannover, Welfengarten 1, D-30167 Hannover, Germany

We investigate the cooling and the phyisics of interactions of metastable neon atoms. We measured elastic and inelastic collisional properties of cold metastable neon ($^3P_2$ state) in a magnetic trap. We found suppression of Penning ionization and achieved a 200-fold increase in phase space density by rf-forced evaporative cooling in the magnetic trap with ^{22}Ne [1]. However, efficiency of evaporative cooling has to be improved in order to reach quantum degeneracy.

Therefore we implemented a crossed optical dipole trap, which we can load from a magneto-optical trap as well as from a magnetic trap. This enables us to investigate the magnetic field dependence of collisional properties of metastable neon. More importantly, we can now trap metastable neon in states which cannot be trapped magnetically.

As a result we trapped, for the first time, neon in the $^3P_0$ metastable state. Measurements of the number decay of trapped atoms will allow to infer the rate coefficient for two-body loss of neon in the $^3P_0$ metastable state for both bosonic isotopes ^{20}Ne and ^{22}Ne. For this purpose, a careful characterization of the optical trap is required.

[1] P. Spoden et al., Phys. Rev. Lett. 94, 223201 (2005)

A 27.7 Fr 12:15 6G

Laser cooling of relativistic C^{3+} beams at the ESR — •M. Bussmann[1], U. Schramm[2], D. Habs[3], M. Steck[3], T. Kühl[3], P. Beller[3], B. Franzke[3], F. Nolden[3], T. Stöhlker[3], W. Nörtershäuser[3], C. Geppert[5], S. Reinhardt[4], S. Karpuk[5], and C. Novotny[5] — [1]Department f. Physik, Ludwig-Maximilians-Universität München, Garching — [2]Forschungszentrum Dresden Rossendorf, Dresden — [3]Gesellschaft f. Schwerionenforschung, Darmstadt — [4]Max-Planck-Institut für Kernphysik, Heidelberg — [5]Institut für Physik, Johannes-Gutenberg-Universität Mainz, Mainz

We report on new results for laser cooling of bunched C^{3+} beams at the ESR stored at an energy of 1.46 GeV. We observe a longitudinal momentum spread one order of magnitude smaller compared to conventional electron cooling.
Using a setup of two cw Ar^+ lasers, one at a fixed frequency, the other constantly detuned with respect to the first, we were able to increase the momentum acceptance of the laser force compared to recent experiemnts [1]. If laser cooling is assisted by moderate electron cooling 3D cold beams can be achieved.
The focus of the talk lies on the dynamical aspects of the transition from temperature dominated beams to space charge dominated beams.

[1] U. Schramm, M. Bussmann, D. Habs, M. Steck, T. Kühl, P. Beller, B. Franzke, F. Nolden, G. Saathoff, S. Reinhardt, S. Karpuk, *AIP Conf. Proceedings* **821** (2006), 501-509

A 28: Collisions with electrons and ions (jointly with MO)

Zeit: Freitag 10:30–12:15 Raum: 5M

Hauptvortrag A 28.1 Fr 10:30 5M

Angular analysis of x–ray emission from excited ionic states with unresolved fine structure — •Andrey Surzhykov[1], Ulrich Jentschura[1], Thomas Stöhlker[2], and Stephan Fritzsche[3] — [1]Max–Planck–Institut für Kernphysik, Heidelberg — [2]Gesellschaft für Schwerionenforschung (GSI), Darmstadt — [3]Universität Kassel

At storage rings, the various processes occurring in relativistic collisions of heavy ions with atomic or electronic targets may result in the production of excited ionic states. The subsequent decay of these excited states leads to emission of one (or several) photons until the ground state is reached. The angular analysis of such a characteristic x-ray emission is a valuable tool for studying the structure and dynamics of highly-charged ions. Quite often, however, the decay photons from two (or more) excited ionic states cannot be distinguished by x-ray detectors and, hence, only "averaged" angular information is available from experiment. In this contribution, we present a theoretical study for the angular distributions of the unresolved characteristic lines and argue that even the "averaged" emission patterns may help us to understand the population–and–decay of high-Z ions. As an example, we present our calculations for the Kα_1 decay of the excited $1s2p_{3/2}J = 1, 2$ states of the helium–like uranium ions U^{90+} produced in the course of two different population processes: (i) the radiative electron capture and (ii) the Coulomb excitation. Experiments concerning these processes have recently been performed at GSI in Darmstadt, and the angular distributions observed have been found to be inconsistent with the predictions of a one–particle model.

A 28.2 Fr 11:00 5M

Photon angular distribution and nuclear-state alignment in nuclear excitation by electron capture — •Adriana Pálffy[1], Zoltán Harman[1], Andrey Surzhykov[1], Ulrich D. Jentschura[1], and Werner Scheid[2] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Institut für Theoretische Physik, Giessen

We investigate the resonant process of nuclear excitation by electron capture (NEEC), in which a free electron is captured into a bound atomic shell with the simultaneous excitation of the nucleus. Partly due to the radiative recombination (RR) background, NEEC has not been observed experimentally yet. In Ref. [1,2] total cross sections for NEEC followed by the radiative decay of the nucleus are presented. The measurement of the angular distribution of the emitted photons in the recombination process offers an useful method of discerning NEEC from RR. With the help of a density matrix formalism the angular distribution of the photons emitted in the radiative decay of the nucleus is derived. We present the anisotropy parameters and the angular distribution of the photons emitted in a radiative E2 decay of the nuclear state for the capture of the electron into the K shell of several bare ions. The angular pattern of the photon emission for NEEC can serve as a signature for the occurrence of the process.

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

[2] A. Palffy, Z. Harman and W. Scheid, Phys. Rev. A 74, in press (2006)

A 28.3 Fr 11:15 5M

A photoemission source for experiments on electron impact ionization of atoms and molecules — •Vladimir Borovik, Toshiyasu Ichioka, Claus Dieter Schröter, Alexander Dorn, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-67119 Heidelberg, Germany

The investigation of single and multiple ionization of atoms by electron impact allows insight into the dynamics of fundamental few-body quantum systems. In the past we have performed these studies combining a standard thermo-cathode electron beam source with a Reaction Microscope (see, e.g., Dürr et al., PRL 96, 243202). In future we aim to improve the electron beam quality concerning the energy definition and timing structure. We therefore have built a photoemission source based on a semiconductor cathode with negative electron affinity (NEA). The design, the preparation procedure of the GaAs crystal

and the resulting beam properties will be presented.

A 28.4 Fr 11:30 5M

Kinematically complete experiments on ground-state dissociation of H_2 molecules by electron impact — •Arne Senftleben[1], Nicole Haag[2], Alexander Dorn[1], Martin Dürr[1], and Joachim Ullrich[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Stockholms universitet, 10691 Stockholm, Sweden

Collisions of molecular hydrogen with 210 eV electrons have been studied kinematically complete, allowing to examine the collision dynamics as detailed as possible. Besides pure ionisation the so-called ground state dissociation channel (GSD) has been investigated where the ionised molecules are excited to the vibrational continuum and subsequently dissociate. This allows to extract the orientation of the molecular axis at the time of the collision. Using a multi-electron recoil-ion momentum spectrometer (reaction microscope) all charged reaction products were detected over a large solid angle. With this technique the GSD of H_2 could be examined in a kinematically complete measurement for the first time. Differential cross-sections were obtained as a function of molecular alignment with respect to the projectile beam.

A 28.5 Fr 11:45 5M

Untersuchung der Endzustände bei der dissoziativen Rekombination von CF^+: Ein verbesserter Detektor zur dreidimensionalen Multi-Fragment-Abbildung — •Mario Mendes[1], Steffen Novotny[1], Oldrich Novotny[1], Iftach Nevo[2], Henrik Buhr[1], Dirk Schwalm[1,2], Daniel Zajfman[2] und Andreas Wolf[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Weizmann Institute of Science, Rehovot, Israel

Zur Untersuchung der dissoziativen Rekombination (DR) wird am Testspeicherring (TSR) des Max-Planck-Instituts für Kernphysik in Heidelberg ein Detektor zur Abbildung der beim DR-Prozess entstehenden neutralen Fragmente verwendet, welcher für eine prinzipiell nicht limitierte Anzahl innerhalb weniger Nanosekunden auftreffender Fragmente Positionen und Auftreffzeiten registriert [1]. Wesentlicher Bestandteil dieses Detektors ist ein System zweier CCD-Kameras, von denen eine mit Hilfe eines schnell schaltbaren Verstärkers geschlossen werden kann. Die Zeitauflösung des Detektors hängt dabei von der Abschaltzeit ab. Diese Abhängigkeit wurde eingehend untersucht und im Rahmen einer konstruktiven Verbesserung des Detektors ausgenutzt. Die Endzustände bei der dissoziativen Rekombination von CF^+ und ihre Winkelverteilungen konnten aus dreidimensionalen Daten bei verschiedenen Elektronenstoßenergien bestimmt werden. Von drei energetisch möglichen Endzuständen werden bei Stoßenergie Null nur zwei beobachtet. Bei hohen Energien variiert das Verzweigungsverhältnis der Endzustände stark.

[1] D. Strasser et al., Rev. Sci. Instrum. **71**, 3092 (2000)

A 28.6 Fr 12:00 5M

Kinematisch vollständige Untersuchung von Zwei-Zentren Effekten bei der simultanen Ionisation von Projektil und Target in H^- - He Stößen — •Thomas Ferger[1], Daniel Fischer[1,2], Michael Schulz[3], Robert Moshammer[1], Alexander B. Voitkiv[1], Bennaceur Najjari[1] und Joachim Ullrich[1] — [1]MPIK-Heidelberg, Germany — [2]Stockholm University, Sweden — [3]UMR Missouri, USA

In diesem Experiment wurde die simultane Ionisation von Projektil und Target in Stößen von H^- mit He bei einer Projektilenergie von 200 keV mit Hilfe eines "Reaktions Mikroskops"kinematisch vollständig vermessen. Betrachtet man das schwach gebundenen Elektron des H^- Projektils (Ionisationspot. = 0,75 eV) als ein quasi freies Elektron so erwartet man, dass die gemessenen vollständig differentiellen Wirkungsquerschnitte (FDCS) für die Ionisation von He vergleichbar sind mit einer Elektronenstoßionisation (e,2e) durch ein freies Elektron bei der entsprechenden Projektilgeschwindigkeit (E_e = 109 eV). Durch die Anwesenheit des Projektilkerns kann zusätzlich der Einfluss des Zwei-Zentren Coulomb-Potentials untersucht werden. Neben der Elektron-Elektron Wechselwirkung treten weitere Beiträge höherer Ordnung auf, die insbesondere in den FDCS der Projektilionisation deutlich werden. Anhand von so genannten Dalitz-Plots wird versucht dieses Vier-Körper Problem auf einfachere Wechselwirkungen zu reduzieren.