

## 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.

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**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 <sup>1</sup> 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 time-dependent 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 <sup>2</sup> 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 laser pulses 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.

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**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.

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**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 and 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 H<sub>2</sub> soll das Verhalten der Elektronen sowohl im Pump- als auch im Probepuls zeitaufgelöst untersucht werden. Das aufgebaute Lasersystem sowie weitere experimentelle Möglichkeiten werden vorgestellt.

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**Time-resolved studies of CH<sub>4</sub> fragmentation in intense laser fields** — ●ULRICH WIEDEMANN<sup>1</sup>, ARTEM RUDENKO<sup>1</sup>, THORSTEN ERGLER<sup>1</sup>, KARL ZROST<sup>1</sup>, BERNOLD FEUERSTEIN<sup>1,2</sup>, CLAUS DIETER SCHRÖTER<sup>1</sup>, ROBERT MOSHAMMER<sup>1</sup>, and JOACHIM ULLRICH<sup>1</sup> — <sup>1</sup>Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — <sup>2</sup>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,  $4 \times 10^{14}$  W/cm<sup>2</sup>, 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 (CH<sub>4</sub><sup>+</sup> => CH<sub>3</sub> + H<sup>+</sup> and CH<sub>4</sub><sup>+</sup> => CH<sub>3</sub><sup>+</sup> + 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 CH<sub>4</sub> 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.

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**Imaging of clusters by femtosecond scattering of intense soft X-rays** — ●EKATERINA EREMINA<sup>1</sup>, CHRISTOPH BOSTEDT<sup>1</sup>, MATTHIAS HOENER<sup>1</sup>, HEIKO THOMAS<sup>1</sup>, THOMAS MÖLLER<sup>1</sup>, TIM LAARMAN<sup>2</sup>, HU-

BERTUS WABNITZ<sup>3</sup>, and ANTONIO RUBENS BRITTO DE CASTRO<sup>4</sup> —  
<sup>1</sup>Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — <sup>2</sup>Max-Born-Institut, Max-Born-Straße 2A, 12489 Berlin, Germany — <sup>3</sup>DESY, Notkestr. 85, 22603 Hamburg, Germany — <sup>4</sup>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<sup>2</sup>) 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<sup>2+</sup> quasimolecule with short intense laser pulses** — •LUIS FERNANDEZ-MENCHERO<sup>1</sup>, HANS JÜRGEN LÜDDE<sup>2</sup>, and TOM KIRCHNER<sup>1</sup> — <sup>1</sup>Institut für Theoretische Physik, TU Clausthal, Leibnizstraße 10, 38678 Clausthal-Zellerfeld — <sup>2</sup>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<sup>2+</sup> 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<sub>2</sub> 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<sub>2</sub> 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 ALJANDRO 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 photoelectron 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.

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**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.

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

**generated plasma in H<sub>2</sub>- and He-droplets** — RUI ALEXANDRE COSTA FRAGA and ●NIKOS PETRIDIS — IKF JWG - Universität Frankfurt

siehe Titel

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**Ionization of helium by 5.9fs elliptical laser pulses** — ●MATHIAS SMOLARSKI<sup>1</sup>, ANDRÉ STAUDTE<sup>2</sup>, MARKUS SCHÖFFLER<sup>1</sup>, OTTMAR JAGUTZKI<sup>1</sup>, REINHARD DÖRNER<sup>1</sup>, PETRISSA ECKLE<sup>3</sup>, PHILIP SCHLUP<sup>3</sup>, JENS BIEGERT<sup>4</sup>, and URSULA KELLER<sup>3</sup> — <sup>1</sup>Institut für Kernphysik, Johann Wolfgang Goethe Universität, Max-Von-Laue-Str. 1, 60438 Frankfurt am Main, Germany — <sup>2</sup>Stacie Institute for Molecu-

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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.