A 12: Posters: Interaction with intense laser pulses

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

A 12.1 Di 16:30 Poster C3

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

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

A 12.2 Di 16:30 Poster C3

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

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

A 12.3 Di 16:30 Poster C3

Photoelectron imaging spectroscopy of potassium atoms with polarization-shaped fs-laser pulses — •Marc Krug, Jens Köhler, Matthias Wollenhaupt, and Thomas Baumert — Universität Kassel, Institut für Physik und Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), Heinrich-Plett-Str. 40, D-34132 Kassel, Germany

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

A 12.4 Di 16:30 Poster C3

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

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

A 12.5 Di 16:30 Poster C3

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

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

A 12.6 Di 16:30 Poster C3

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

Generating fast electrons from table top sources powered by strong laser systems is becoming an interesting tool for experimentalists. In most cases the effect of the wake field acceleration is used [1]. In our present work, we show an alternative way to generate distributions of highly energetic electrons accelerated by strong laser fields where the main processes takes place on the nanometer scale. We solve the multi dimensional time dependent Schrödinger equation on large spatial grids and show how electron wave packet scattering on Coulomb-like potentials (ions) in strong laser fields leads to resonance phenomena and distributions of fast electrons. In previous works [2] only one dimensional systems have been studied. We now demonstrate that carefully chosen scattering geometries and additional external electric fields allow to extend these results to realistic setups. In order to make predictions the angular resolved energy spectrum is analyzed.
[1] Th. Katsouleas, Nature 2004, Vol. 341 p. 516
[2] H.J. Kull and V.T. Tikhonchuk, Phys. Plas. **12,** 063301 (2005)

A 12.7 Di 16:30 Poster C3

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

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

A 12.8 Di 16:30 Poster C3

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

Die Rückstoßionen Impulsspektroskopie hat sich, insbesondere in Kombination mit effizienten Elektronen-Spektrometern (so genannte Reaktions-Mikroskope oder COLTRIMS Spektrometer), als ein mächtiges Werkzeug zur Untersuchung von atomaren und molekularen

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

A 12.9 Di 16:30 Poster C3

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

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

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

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

A 12.10 Di 16:30 Poster C3

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

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

A 12.11 Di 16:30 Poster C3

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

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

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

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

A 12.12 Di 16:30 Poster C3

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

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

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

A 12.13 Di 16:30 Poster C3

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

Non-sequential double ionization (NSDI) of atoms by intense linearly polarized laser fields has remained one of the central and most controversial topics in strong-field physics for more than two decades. Though most of the experimental findings are in good overall agreement with a semiclassical "recollision" model, the current understanding of NSDI is far from being complete. Here we present the results of a kinematically complete experiment on NSDI of He by 800 nm 25 fs 1.5 PW/cmˆ2 laser pulses. In contrast to earlier experimental results for Ne and Ar, we observe a pronounced v-shaped structure in the two-electron momentum distributions along the laser polarization ("longitudinal") direction, which was predicted by several S-matrix calculations, and by the numerical solutions of the time-dependent Schrödinger equation. This pattern, indicating that both electrons have non-equal longitudinal momenta in the final state, can be explained by the role of the Coulomb repulsion and typical (e,2e) recollision kinematics.

A 12.14 Di 16:30 Poster C3

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

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

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

A 12.15 Di 16:30 Poster C3

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

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

examined both from the ground and exited states.

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

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

A 12.16 Di 16:30 Poster C3

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

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

A 12.17 Di 16:30 Poster C3

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

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

A 12.18 Di 16:30 Poster C3

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

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

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

A 12.19 Di 16:30 Poster C3

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

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