A 20: Atomic systems in external fields

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

A 20.1 Tue 16:30 Empore Lichthof

Following the Evolution of ICD in Time — •Fawad Karimi, Markus Pfau, Martin Ranke, Anastasios Dimitriou, and Ulrike Frühling — Institute of Experimental Physics, University of Hamburg, Center of Ultrafast Imaging (CUI), Center for Free Electron Lasers (CFEL)

Interatomic Coulombic Decay (ICD), a non-local auto-ionization process predicted by Lorenz Cederbaum in 1997, is an efficient decay channel used by atoms in loosely bound van der Waals rare gas molecules and clusters. We aim to investigate the ICD lifetime in Neon-Krypton dimers. The dimers are formed in a co-expansion of a NeKr gas mixture under high pressure through an aperture in vacuum. Ultrashort XUV pulses generated by the process of HHG initiates the ICD process by ionizing an inner valence electron of Ne. The relaxation energy of Ne is transferred to the neighbouring Kr atom in form of a virtual photon. The whole process leaves two ionized atoms in a dimer which consequently undergoes a coulomb explosion. The continuum electron wave packet can be probed with an intense THz field, which is superimposed with the XUV pulses. The temporal profile of this wave carries the desired temporal information about the underlying dynamics.

A 20.2 Tue 16:30 Empore Lichthof

Simulation of attosecond-streaking in dielectric nanospheres — •Lennart Seiffert[1], Sergey Zherebtsov[2], Philipp Rupp[2], Philipp Henning[1], Matthias Kling[2], and Thomas Fennel[1] — [1]Universität Rostock — [2]Ludwig-Maximilians-Universität München

Electron transport in dielectrics is of fundamental importance for electronic devices and plays a crucial role in photoelectron spectroscopy and microscopy. The effective escape depth of photoemission from dielectrics depends strongly on inelastic collisions that typically take place on attosecond timescales and may thus be accessible with attosecond metrology [1]. So far, attosecond-streaking has been applied to atomic systems to study ionization delays [2] and utilized to investigate electron transport in metals [3] and adlayer-covered metals [4]. A promising approach to establish attosecond-streaking in dielectrics relies on the utilization of isolated nanosolids to circumvent space charge problems. Here, we simulate attosecond-streaking at isolated SiO_2 nanospheres and investigate the impact of electron transport on the streaking spectra. Our semi-classical Monte-Carlo trajectory simulations [5] support that attosecond-streaking can be used as a universal tool to directly clock the inelastic scattering time in dielectrics [6].

[1] R. Kienberger et al., Nature 427, 817-821 (2004)
[2] M. Schultze et al., Science 328, 1658-1662 (2010)
[3] A. L. Cavalieri et al., Nature 449, 1029-1032 (2007)
[4] S. Neppl et al., Nature 517, 342-346, (2015)
[5] F. Süßmann et al., Nat Commun. 6, 7944 (2015)
[6] F. Calegari et al., in preparation

A 20.3 Tue 16:30 Empore Lichthof

Using GAS-CI to extract atomic and molecular structure factors for tunneling ionization — •Sebastian Bauch[1], Lun Yue[2], Henrik Larsson[3], Michael Bonitz[1], and Lars Bojer Madsen[2] — [1]Institut für Theoretische Physik und Astrophysik, CAU Kiel, Germany — [2]Institute for Physics and Astronomy, Aarhus University, Denmark — [3]Institut für Physikalische Chemie, CAU Kiel, Germany

The accurate description of tunneling ionization of many-electron atoms and molecules is a challenging task. The recently formulated weak field asymptotic theory (WFAT) [1] addresses this topic and allows for the calculation of ionization rates of molecules with inclusion of electron correlation. One of its central ingredients is the asymptotic form of the Dyson orbital. Its accurate determination by means of standard tools is in many cases not possible due to the commonly chosen localized basis functions. These offer a highly accurate description close to the nuclei but fail to reproduce the wave function at large distances. In order to circumvent this problem for diatomic molecules, we therefore employ the generalized-active-space configuration interaction (GAS-CI) framework [2] applied within a prolate spheroidal grid [3]. We present the essence of our method and demonstrate its application to H_2 and larger systems. The ionization rates for different orientations of the molecule are extracted.

[1] O.I. Tolstikhin, L.B. Madsen, and T. Morishita, PRA 89 013421 (2014) [2] D. Hochstuhl, and M. Bonitz, PRA 86 053424 (2012); S. Bauch, L.K. Sørensen, and L. B. Madsen, PRA 90 062508 (2014) [3] H.R. Larsson, S. Bauch, and M. Bonitz, arXiv:1507.04107 (2015)

A 20.4 Tue 16:30 Empore Lichthof

Dirac: Computer algebra tools for studying the properties of hydrogen-like atoms — •Jiri Hofbrucker[1,2], Andrey Surzhykov[1], and Stephan Fritzsche[1,2] — [1]Helmholtz Institute Jena, Germany — [2]University of Jena, Germany

The model of hydrogen-like ions plays a significant role in various research fields such as atomic and molecular physics, plasma physics or astrophysics. Hence, an easy access to the analytical as well as numerical properties of the model is of the interest of a wide community of researchers. Here, we present an updated and extended Mathematica version of the algebraic software DIRAC, which aims to provide the user with interactive tools for studying the properties of hydrogen-like atoms. Apart from the original procedures[1][2] including the Coulomb-field solutions to the Schroedinger and Dirac equations, Greens functions and radial integrals, this version adds on a number of high level procedures to describe the total and angular differential cross sections for the interaction of radiation with hydrogen-like atoms. Moreover, the documentation centre for this package has been updated to deliver a clear description of individual functions in order to offer a user friendly environment of the DIRAC package. [1] A. Surzhykov, P. Koval, S. Fritzsche, Comput. Phys. Comm. 165 (2005) 139. [2] S. McConnell, S. Fritzsche, A. Surzhykov, Comput. Phys. Comm. 181 (2010) 711-713

A 20.5 Tue 16:30 Empore Lichthof

Instabilities and Inaccuracies of Multi-Configuration Time-dependent Hartree-Fock Applied to Atomic Systems — •Christopher Hinz, Sebastian Bauch, and Michael Bonitz — ITAP, Christian-Albrechts-Univeristät Kiel, Leibnizstraße 15, 24098 Kiel

We demonstrate that the widely used multi-configuration time-dependent Hartree-Fock method [1] is restricted to a certain class of applications and fails for scenarios where small parts of the wave function are important, such as typically occurring in strong-field physics and attosecond methodology. By using illustrative and physically relevant examples, we show the existence of serious instabilities in the method itself and demonstrate that for several important cases the assumed convergence of the method with respect to electron correlations is virtually absent [2,3].

[1] D. Hochstuhl, C. Hinz and M. Bonitz, EPJ ST **223**, 177-336 (2014)
[2] C. M. Hinz, S. Bauch, and M. Bonitz, submitted to *JPCS* (2015)
[3] C. M. Hinz, S. Bauch, and M. Bonitz, submitted to *Phys. Rev.* A (2016)

A 20.6 Tue 16:30 Empore Lichthof

Frequency tunable microwave field imaging with sub-100 μm resolution using atomic vapor cells — •Andrew Horsley, Guan-Xiang Du, and Philipp Treutlein — University of Basel, Switzerland

We have developed a technique for imaging microwave magnetic fields using alkali vapor cells, detecting microwaves through Rabi oscillations driven on atomic hyperfine transitions. This could prove transformative in the design, characterisation, and debugging of microwave devices (e.g. atom chips or ion traps), as there are currently no established microwave imaging techniques. Our technique may also find applications in medical imaging. We have built a high resolution imaging system, whose $50 \times 50 \times 140\,\mu m^3$ spatial resolution, $1\,\mu T/Hz^{1/2}$ sensitivity, and $150\,\mu m$ approach distance are now sufficient for characterising a range of real world devices at fixed microwave frequencies [1].

Frequency tunability is essential for wider applications, however we can only detect microwaves that are resonant with an atomic transition. Our solution is to use a large dc magnetic field to Zeeman shift the hyperfine ground state transitions to any desired frequency. In addition to high resolution images of 6.8 GHz microwave fields, we present results from a proof-of-principle setup, where we have used a 0.8 T solenoid to detect microwaves from 2.3 to 26.4 GHz.

[1] A. Horsley, G.-X. Du and P. Treutlein, *Imaging of Electromagnetic Fields in Alkali Vapor Cells with sub-100 μm Resolution,* New Journal of Physics, 17(11), 112002, (2015)

A 20.7 Tue 16:30 Empore Lichthof

Phase-of-the-phase spectroscopy in the multiphoton regime — •Mohammad Adel Almajid and Dieter Bauer — Institut für Physik , Universität Rostock , Rostock 18051, Deutschland

Recently, phase-of-the-phase (PoP) spectroscopy has been introduced and applied to the tunneling regime of strong-field ionization [1]. Briefly, the momentum-resolved photoelectron yield as a function of the relative phase between the strong ω and weak 2ω component of a colinearly polarized ω-2ω two-color pulse is measured and Fourier-transformed. This tells us how much and with which phase lag the yield changes with varying relative phase (cf. talk by Slawomir Skruszewicz). The canonical two-club structure of PoP spectra in the tunneling and rescattering regime were analyzed in Ref. [1]. On our poster, we present the corresponding results for the multiphoton regime. We find that the alternating PoP along the above-threshold ionization rings generates a characteristic checkerboard pattern in the PoP spectra, which corresponds to the "carpet" structure in ordinary photoelectron spectra found previously [2]. The pattern is most clearly visible when the strong-field approximation (SFA) is applied. Within SFA, even an analytical formula can be derived. However, results obtained via the ab initio solution of the time-dependent Schrödinger equation show a more complex behavior of the momentum-resolved PoP due to long-range Coulomb effects on the outgoing electrons.

[1] S. Skruszewicz, et al. Phys. Rev. Lett. 115, 043001 (2015)
[2] Ph. A. Korneev, et al. Phys. Rev. Lett. 108, 223601 (2012)

A 20.8 Tue 16:30 Empore Lichthof

Slow electrons from non-adiabatic transitions in a two-electron system — •Qi-Cheng Ning, Koudai Toyota, Ulf Saalmann, and Jan-Michael Rost — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden, Germany

Atomic systems exposed to short high-frequency laser pulses release unexpectedly slow electrons which are the consequence of non-adiabatic transition [1,2]. In single-active-electron atomic system, the relevant mechanisms can be clearly formulated and explained by means of the envelope hamiltonian defined recently [3].

Here we extend the study to a two-electron model atom. Both double and single ionization have been calculated and show the peaks of slow electrons. It is confirmed these slow electrons are also generated from non-adiabatic transitions. The role played by electron-electron correlation has been studied.

[1] M. Førre, S. Selstø, J. P. Hansen, and L. B. Madsen, Phys. Rev. Lett. **95**, 043601 (2005).
[2] K. Toyota, O. I. Tolstikhin, T. Morishita, and S. Watanabe, Phys. Rev. Lett. **103**, 153003 (2009).
[3] K. Toyota, U. Saalmann, and J. M. Rost, New J. Phys. **17**, 073005 (2015).

A 20.9 Tue 16:30 Empore Lichthof

Characterization of the Mainz atomic magnetometer for GNOME — •Hector Masia-Roig, Arne Wickenbrock, and Samer Afach — Johannes Gutenberg-Universität Mainz

GNOME is a novel experimental scheme which enables the investigation of exotic spin couplings between nuclei and exotic fields generated by astrophysical sources measuring spin precession. It consist of a network of geographically separated (>100km), time synchronized, ultrasensitive ($\sim fT/\sqrt{Hz}$) optical magnetometers in a magnetically shielded environment. Such a configuration enables the study of global transient effects.

Several atomic magnetometric setups are currently under construction around the globe in order to complete a reliable network for the successful characterization of hypothetical exotic fields. Here is presented the current work of the atomic magnetometer constructed in Mainz as a part of the GNOME collaboration. The main characteristics of the magnetometer, such as sensitivity, response to pulses, long term stability and sources of noise are discussed. These quantities are related to the sensitivity of the network to global transient effects.