A 16: Interaction with strong or short laser pulses I

Time: Wednesday 11:00–13:15 Location: a320

Invited Talk A 16.1 Wed 11:00 a320

Photoionization dynamics of many-electron atoms: an accelerated Green functions approach — •Michael Bonitz, Niclas Schlünzen, Jan-Philip Joost, and Maximilian Rodriguez Rasmussen — Institut für Theoretische Physik und Astrophysik, Universität Kiel, Leibnizstr. 15

The accurate description of the nonequilibrium dynamics of correlated electrons in atoms under laser excitation remains a key topic in many fields. Among others, the nonequilibrium Green functions (NEGF) method has proven to be a powerful tool to capture electron-electron correlations [1]. However, NEGF simulations are computationally expensive due to their T^3 scaling with the simulation duration T. With the introduction of the generalized Kadanoff-Baym ansatz [2] (GKBA), T^2 scaling could be achieved for second order Born (SOA) selfenergies [3], which has substantially extended the scope of NEGF simulations. Recently [4], we could achieve linear scaling with SOA and even GW selfenergies which is expected to lead to breakthroughs for simulating the correlated electron dynamics.

[1] K. Balzer and M. Bonitz, Lect. Notes Phys. **867** (2013)
[2] P. Lipavský *et al.*, Phys. Rev. B **34**, 6933 (1986)
[3] S. Hermanns, K. Balzer, and M. Bonitz, Phys. Scripta **T151**, 014036 (2012)
[4] N. Schlünzen *et al.*, submitted for publication, arXiv:1909.11489 (2019)

A 16.2 Wed 11:30 a320

Revealing the strongly suppressed laser-coherent photoelectron signal using phase-of-the-phase spectroscopy — •Vasily Tulsky, Bennet Krebs, Felix Trepkau, Josef Tiggesbäumker, and Dieter Bauer — University of Rostock, 18051 Rostock, Germany

When a many-electron system is exposed to intense laser radiation, the generated photoelectron spectrum may include a significant or even dominant contribution of laser-incoherent electrons. Those can originate from thermal emission (thus, initially incoherent) or be influenced by multiple scattering before reaching the detector (therefore, losing the coherence). We propose a way to study the coherent part of photoelectron spectra using the phase-of-the-phase (PoP) technique [1-3]. We demonstrate that PoP can be successfully applied even when the incoherent part of the photoelectron signal appears to be dominant [4].

[1] S. Skruszewicz, J. Tiggesbäumker, K.-H. Meiwes-Broer, M. Arbeiter, Th. Fennel, and D. Bauer, Phys. Rev. Lett. 115, 043001 (2015)
[2] M. A. Almajid, M. Zabel, S. Skruszewicz, J. Tiggesbäumker and D. Bauer, J. Phys. B 50, 19 (2017)
[3] V. A. Tulsky, M. A. Almajid, D. Bauer, Phys. Rev. A 98, 053433 (2018)
[4] V. A. Tulsky, B. Krebs, J. Tiggesbäumker, D. Bauer, arXiv:1911.0047 (2019) (submitted to J. Phys. B)

A 16.3 Wed 11:45 a320

A novel method to construct analytical solutions of the Dirac Equation — •Andre Gontijo Campos — Max Planck institute for Nuclear Physics

The complexity of the structure of the Dirac equation, which is a system of four coupled differential equations, renders it very difficult to study. The number of closed-form solutions is very limited due to the intricate structure of Dirac matrices, which couple the four components of the spinorial wave function. For this reason, only highly symmetric systems can be studied by analytical means; the mathematical description of more realistic systems should be based on approximation methods such as semi-classical theory or numerical calculations. However, the smallness of the time scale of relativistic electron dynamics renders the numerical solution notoriously difficult, requiring substantial computer resources. Here, we provide a very powerful method to arrive at the sought-after general analytical solutions to the Dirac equation, which fully explores the geometry of the Lorentz group. For instance, we construct time-dependent electromagnetic fields that coherently steer the electron's spinorial wave function to follow a given path. Moreover, we also present solutions involving a plane electromagnetic wave and a combination of generally inhomogeneous electric and magnetic fields. The newly developed solutions unravel exciting new insights on the complex quantum dynamics of relativistic electrons. The presented method constitutes an important tool with a broad range of applications.

A 16.4 Wed 12:00 a320

Excitations of forbidden transitions by twisted light in different polarization states — •Sabrina A.-L. Schulz[1,2], Anton A. Peshkov[1,2], Robert A. Müller[1,2], and Andrey Surzhykov[1,2] — [1]PTB Braunschweig, Germany — [2]TU Braunschweig, Germany

In recent years the interest in twisted light has been steadily increased both in experiment and theory. Twisted (or vortex) light beams differ substantially from plane waves: twisted photons with helical phasefronts carry nonzero projection of orbital angular momentum (OAM) onto their propagation direction, and their characteristic intensity profile has an annular character with a minimum in the center. The combination of these properties makes twisted light excellent candidates for applications in precision experiments. In this contribution, we study the excitation of dipole-forbidden transitions in a single trapped atom by using twisted Bessel beams. A transition rate is derived for the general case when light propagation direction does not coincide with the atomic quantization axis defined by an applied magnetic field. Particular emphasis is paid to the electric octupole (E3) transition $^2S_{1/2} \rightarrow {}^2F_{7/2}$ in a single trapped $^{171}\mathrm{Yb}^+$ ion, driven by linearly, radially, or azimuthally polarized Bessel beams. The work shows that the excitation rate for twisted light can be significantly enhanced under certain orientations of the external magnetic field.

A 16.5 Wed 12:15 a320

Theoretical Prediction of the Attoclock Angle — •Soumi Dutta, Ulf Saalmann, and Jan Michael Rost — MPI für Physik komplexer Systeme , Nöthnitzer Str. 38, 01187 Dresden, Germany

An intense, low-frequency, elliptically-polarized laser field lets an electron tunnel from an atom and drives it on a quivering trajectory. The asymptotic angle, measured in the famous attoclock experiment, indicating the electron's release time, is spoiled by the so-called laser-Coulomb interaction. The trajectory from a fully equivalent description with the time-dependent Kramers-Henneberger potential, shows a remarkable similarity with a conventional Kepler hyperbola, albeit with some notable deviations. We discuss those deviations, devise a correction compensating for those and give an (approximate) analytical expression for the attoclock angle.

A 16.6 Wed 12:30 a320

Intra-cavity velocity-map imaging at a rate of 100 MHz — •Jan-Hendrik Oelmann, Janko Nauta, Alexander Ackermann, Patrick Knauer, Thomas Pfeifer, and José R. Crespo López-Urrutia — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Velocity-map imaging of xenon [1-3] is performed in the focus of a femtosecond enhancement cavity. The 100 MHz repetition rate of our frequency comb laser enables the detection of photoelectrons from multiphoton ionization even at very low intensity levels well below $10^{12}\,\mathrm{W/cm^2}$ [4]. Because of the highly nonlinear nature of the multiphoton ionization process, electron count rates would dramatically drop at such low laser intensities. For conventional amplified femtosecond laser systems at kHz repetition rates, data acquisition time then increases to technically non-manageable levels. Our setup overcomes this limitation and extends the accessible intensity range to much lower values. Recent results and developments towards the next generation of our experimental setup to study intra-cavity near-threshold ionization and multiphoton excitation will be presented.

[1] H. Helm et al., Phys. Rev. Lett. 70(21), 3221 (1993).
[2] V. Schyja et al., Phys. Rev. A 57(5), 3692 (1998).
[2] B. Wolter, Phys. Rev. X 5(2), 21034 (2015).
[4] J. Nauta et al., *in preparation.*

A 16.7 Wed 12:45 a320

Relativistic analytical model of multi-electron atoms — •Kamil D Dzikowski, Oleg D Skoromnik, Natalia S Oreshkina, and Christoph H Keitel — Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg, Germany

We develop a fully relativistic analytical model for computation of observable characteristics of multi-electron atoms and ions. We employ a complete hydrogen-like basis with an effective nuclear charge parameter for the construction of a perturbation series in the secondary-quantized representation. We study the accuracy of the leading-order approximation for the total binding energies, electron densities, atomic scattering factors and spectra of highly charged ions. The accuracy of calculated characteristics is comparable with the one obtained via advanced numerical solutions of Hartree-Fock equations and thus can replace semi-classical models like the Thomas-Fermi-Dirac model for all applications where they are still utilized.

A 16.8 Wed 13:00 a320

Controlling collective enhancement of above threshold ionization by resonantly exciting helium droplets — •Rupert Michiels[1], Mahmoud Abu-samha[2], Lars Bojer Madsen[3], Ulrich Bangert[1], Marcel Binz[1], Lukas Bruder[1], Carlo Callegari[4], Rowan Duim[1], Raimund Feifel[5], Michele Di Fraia[4], Aaron Cristopher LaForge[6], Paolo Piseri[7], Oksana Plekan[4], Kevin Charles Prince[4], Richard James Squibb[5], Stefano Stranges[8], Daniel Uhl[1], Andreas Wituschek[1], Marcel Mudrich[3], and Frank Stienkemeier[1] — [1]University of Freiburg, Germany — [2]American University of the Middle East, Kuwait — [3]Aarhus University, Denmark — [4]Elettra-Sincrotrone Trieste, Italy — [5]University of Gothenburg, Sweden — [6]University of Connecticut, USA — [7]Università degli Studi die Milano, Italy — [8]University Sapienza Rome, Italy

Condensed matter, especially clusters and nanodroplets, holds the promise of enhancing high-order nonlinear optical effects due to their high local density. Here, we report on the observation of enhanced intensity from the emission of above threshold photoelectrons (ATI). ATI electrons are created by ionizing multiply excited helium nanodroplets in the 1s4p state using 400 nm laser radiation. The intensity of high-order ATI electrons is shown to be enhanced by several orders of magnitude when compared to excited helium in the gasphase. Furthermore, we show that the strength of the ATI enhancement can be tuned by changing the total number of excited atoms in the droplet.