A 4: Atomic systems in external fields

Time: Monday 10:30–12:30 Location: S HS 3 Physik

Invited Talk A 4.1 Mon 10:30 S HS 3 Physik

Odd electron wave packets from cycloidal ultrashort laser fields — •Stefanie Kerbstadt, Kevin Eickhoff, Tim Bayer, and Matthias Wollenhaupt — Carl von Ossietzky Universität Oldenburg, Oldenburg

By combining bichromatic white light supercontinuum polarization pulse shaping with high resolution photoelectron tomography, we devise a general optical scheme [1] for three-dimensional quantum control. The scheme is exemplified on an atomic model system to create and manipulate carrier-envelope phase (CEP)-sensitive electron wave packets with arbitrary rotational symmetry. In the experiments, we use CEP-stable bichromatic counter- and corotating femtosecond laser pulses with continuously tunable center frequencies to generate 7-fold rotational symmetric and completely asymmetric photoelectron momentum distributions from multiphoton ionization of sodium atoms. To elucidate the physical mechanisms, we investigate the interplay between the symmetry properties of the driving field and the resulting electron wave packets by varying the optical field parameters. In addition, the generated photoelectron wave packets are shown to be a suitable tool for holographic and spectroscopic measurements of relative quantum phases, as demonstrated on excited Rydberg states.

[1] S. Kerbstadt et al., Ultrashort polarizationtailored Bichromatic, Opt. Express 25(11), 12518-12530 (2017).

A 4.2 Mon 11:00 S HS 3 Physik

Imaging multiple Rydberg wave packets from shaper-generated two-color femtosecond pump-probe sequences — •Kevin Eickhoff, Stefanie Kerbstadt, Lukas Gabrisch, Tim Bayer, and Matthias Wollenhaupt — Carl von Ossietzky Universität, Oldenburg

Background-free detection of Rydberg dynamics is performed using shaper-generated bichromatic linearly and circularly polarized femtosecond pump-probe pulse sequences. We combine a bichromatic white light polarization pulse shaping scheme with angle- and energy-resolved photoelectron imaging to map the resulting Rydberg wave packet dynamics. Photoelectron momentum distributions from linearly polarized bichromatic fields feature pronounced time-, energy- and angle-dependent dynamics, which result from the coherent superposition of s-, d- and g-type photoelectron wave packets from ionization of the Rydberg np- and nf-series. Detailed analysis of the highly differential data allows us to extract the dynamics of the involved Rydberg wave packets separately. The results are verified by measurements with circularly polarized pump-probe pulse sequences which exclusively address the Rydberg nf-series and probe its dynamics into the g-type continuum. Further studies with CEP-stabilized bichromatic femtosecond pulse sequences and holographic measurements of the Rydberg wave packet's quantum phases are presented.

A 4.3 Mon 11:15 S HS 3 Physik

Extracting laser-coherent information from a photoelectron spectrum of a complex target using the phase-of-the-phase — •Vasily Tulsky and Dieter Bauer — University of Rostock, Rostock, Germany

Electron spectra produced from many-electron systems irradiated by an intense laser field can include a significant or even dominant fraction of laser-incoherent electrons that are influenced by multiple scattering on other atoms or produced by thermal emission. A possible way to subtract all the laser-incoherent part is the application of the recently developed phase-of-the-phase (PoP) technique [1-3]. In order to demonstrate it, we model strong-field ionization of argon atoms trapped inside helium droplets. Corresponding photoelectrons experience multiple elastic scattering on helium atoms before reaching the detector and generate a dominant incoherent signal. We show that the PoP successfully reveals the features encoded in the coherent part of the total output signal.

[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).

A 4.4 Mon 11:30 S HS 3 Physik

Topological effects in high-harmonic generation by planar sheets — •Helena Drüeke and Dieter Bauer — Institute of Physics, University of Rostock, 18051 Rostock, Germany

The vacant terrain between traditional strong-field attosecond and condensed matter physics is currently explored with an increasing effort both experimentally and theoretically. As topological effects play an important role in modern condensed matter physics, questions about their consequences for typical strong-field observables such as high-harmonic spectra naturally arise. Recently, we investigated the simplest system with topological edge states in a laser field (i.e., linear chains, [1,2]) and found huge differences in the harmonic yield from different topological phases. We now extend this work towards 2D materials. We are interested in the strong-field laser-driven transport along the edges and its signatures in high-harmonic spectra. We use time-dependent density functional theory, as it is not clear a priori whether the common tight-binding models are applicable for strong fields.

[1] Dieter Bauer and Kenneth K. Hansen, *High-harmonic generation in solids with and without topological edge states*, Phys. Rev. Lett. 120, 177401 (2018)

[2] Helena Drüeke and Dieter Bauer, *(manuscript in preparation)*

A 4.5 Mon 11:45 S HS 3 Physik

Many-body Kinetics of Dynamic Nuclear Polarization by the Cross Effect — •Federica Raimondi, Alexander Karabanov, Daniel Wisniewski, Igor Lesanovsky, and Walter Kockenberger — School of Physics & Astronomy, University of Nottingham, UK

Dynamic Nuclear Polarization (DNP) provides significant signal enhancement compared to conventional thermal polarization techniques used in typical nuclear magnetic resonance applications. The Cross Effect (CE) DNP mechanim, involving triple spin-flips between two interacting electrons and a nucleus, is the most efficient at low temperature and microwave irradiation amplitude. In silico optimization of parameters affecting CE enhancement, such as radical concentration and design, requires simulation of large spin systems. However, solving the Liouville-von Neumann equation for such systems quickly becomes intractable. Here, we show that the non-equilibrium nuclear polarization build-up is effectively driven by incoherent Markovian dissipative processes. These can be modelled using a highly efficient classical Kinetic Monte Carlo algorithm, which can accurately simulate systems consisting of over 100 spins within a reasonable time frame. With our theoretical approach, we have for the first time been able to study many-body processes such as spin diffusion.

We have since started to develop a fast simulation algorithm for the experimentally more relevant case of Magic Angle Spinning CE-DNP.

A 4.6 Mon 12:00 S HS 3 Physik

Penning Traps in Gravity: Implications for Free Electron g-factor Measurements — •Sebastian Ulbricht[1,2], Robert A. Müller[1,2], and Andrey Surzhykov[1,2] — [1]Physikalisch-Technische Bundesanstalt, Germany — [2]Technische Universität Braunschweig, Germany

Today, the gyromagnetic ratio of a free electron is known to a very high accuracy of g/2=1.001 159 652 180 73 (28) [1] and the improvement of this value is still an ongoing process in modern research. The g-factor is currently determined by spectroscopy of spin-flip and cyclotron transitions of a single electron in a Penning trap. These experiments, however, are not performed in an isolated environment, but in the gravitational field of the Earth. In this contribution, therefore, we present investigations of gravitational effects on the trapped electron *and* the Penning trap itself. More specifically, we take into account gravitational effects on the electromagnetic field of the Penning trap, which in turn effect the motion of the electron. We derived the resulting relativistic corrections of order $1/c^2$ to transition frequencies, used to determine the free electron g-factor. As a consequence an extension of the well known g-factor formula introduced by L. S. Brown and G. Gabrielse [2] is presented.

[1] D. Hanneke, S. Fogwell, and G. Gabrielse, Phys. Rev. Lett. **100**, 120801 (2008).

[2] L. S. Brown and G. Gabrielse, Rev. Mod. Phys. **58**, 233 (1986).

A 4.7 Mon 12:15 S HS 3 Physik

Hamiltonian engineering for studying many-body dynamics in strongly interacting Rydberg systems — •Nithiwadee Thaicharoen[1], Renato Ferracini Alves[1], Titus Franz[1], Sebastian Geier[1], Alexander Müller[1], Andre Salzinger[1], Annika Tebben[1], Clément Hainaut[1], Gerhard Zürn[1], and Matthias Weidemüller[1,2] — [1]Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — [2]Shanghai Branch, University of Science and Technology of China, Shanghai 201315, China

Dipolar interacting Rydberg spin systems have been ideal platforms to study non-equilibrium phenomena of isolated quantum systems. Their tunable strong, long-range interactions provide new opportunities to investigate the dynamics of strongly correlated many-body quantum systems with beyond nearest-neighbor coupling. Here, the system can either relaxes to a thermal equilibrium or reaches nonthermal-fixed points, where effect of disorders, external fields and fluctuations play important roles. In this work, we present an experimental realization of a dipolar spin-1/2 model by coupling two strongly interacting Rydberg states utilizing a microwave field. We propose a scheme to engineer the Hamiltonian of the system using dynamical pulse sequence of the microwave field to identify if the initial order of the system persist after time evolution of the system. The global magnetization and its variance extracted from state-selective detection reveal if the system is localized or reaches a thermal equilibrium.