A 45: Atomic systems in external fields I

Time: Friday 11:00–12:30 Location: B 302

Invited Talk A 45.1 Fri 11:00 B 302

Attosecond time-resolved high-resolution spectroscopy of two-electron dynamics in helium, and impulsive control of light — •Thomas Pfeifer — MPI für Kernphysik, Heidelberg

The dynamical motion of electrons governs the physics of processes as fundamental as the absorption of visible light (e.g. creating color) and the making and breaking of molecular bonds (e.g. chemical reactions). In almost all atoms or molecules, electronic excitations are based on the concerted, quantum-correlated, motion of two or more electrons, due to the strong and long-range electron–electron Coulomb interaction and the fermionic exchange symmetry (Pauli principle). It has thus been a long-standing dream to temporally resolve, understand, and control the correlated quantum-mechanical wave function of two or more electrons. Here, we present an experimental spectroscopy method to measure this correlated motion of two electrons bound to a Helium atom. By using tunable laser intensity, we directly observe the continuous transition from weak and perturbative to strong coupling with Rabi cycling (Autler–Townes doublet formation) among autoionizing states. We also use our measurement scheme and its sensitivity to the quantum phase of the excited states to reconstruct a two-electron wavepacket, which can be shaped by the visible laser field, with corresponding implications for the control of covalent molecular bonds, typically consisting of two electrons. We also find a mechanism to variably tune the Fano absorption profiles (inversion and Lorentz-profile conversion), which has far-reaching consequences for the control of absorption of radiation throughout the entire spectrum in general.

A 45.2 Fri 11:30 B 302

Strong-field response of a system with resonance in the continuum. — •Maria Tudorovskaya and Manfred Lein — Institut für Theoretische Physik and Centre for Quantum Engineering and Space-Time Research (QUEST), Leibniz Universität Hannover, Appelstr. 2, 30167 Hannover, Germany

If an atom is subject to a strong oscillating field, it can emit high-harmonic radiation due to the ionization and the following recombination. We consider high-harmonic generation (HHG) in a system with a metastable resonance state in the continuum.

We solve the time-dependent Schrödinger equation numerically in 1D and 2D. We consider a model system describing ions in a Mn plasma [1]. In the system, noticeable increase of HHG at frequencies around the resonance is found. For few-cycle driving pulses, emission takes the form of a short burst.

With an additional XUV driving field, Rabi oscillations can be induced between the ground state and the resonance, affecting the resulting spectrum. Because the decay of the resonance, the oscillation amplitude is damped. Due to the combined effect of the fields, the intensity of the harmonics in the plateau region can be significantly increased.

[1] R. A. Ganeev, et al., Opt. Express 20, 25239 (2012).

A 45.3 Fri 11:45 B 302

Phase-controlled electron acceleration from dielectric nanoparticles in intense few-cycle laser pulses — •Lennart Seiffert[1], Frederik Süssmann[2], Sergey Zherebtsov[2], Jürgen Plenge[3], Eckart Rühl[3], Matthias Kling[2], and Thomas Fennel[1] — [1]Universität Rostock, 18051 Rostock, Germany — [2]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany — [3]Freie Universität Berlin, 14195 Berlin, Germany

The electron emission from atoms and molecules in intense few-cycle laser pulses can be precisely controlled (with sub-fs resolution) by the carrier-envelope-phase [1]. Recently, it has been shown that such pulses also allow us to unravel and control ionization processes in more complex many particle systems, such as silica nanoparticles [2]. Here, we investigate the electron acceleration from laser driven dielectric nanoparticles, where near-field enhancement at the surface leads to the emission of high energy electrons. The electron dynamics is modelled using a quasi-classical trajectory-based mean field Monte-Carlo approach [3], which is extended to account for propagation effects of the near-fields. The size-dependent structure of the near-fields results in strong changes of the angular resolved electron spectra for particle diameters in the range $100 - 400\,\mathrm{nm}$. A detailed understanding of the contributing emission procceses, such as direct, thermal, and field enhanced emission can be deduced from the electron trajectory analysis.

[1] G. G. Paulus et al., Phys. Rev. Lett. 91:253004 (2003)
[2] S. Zherebtsov et al., Nature Phys. 7:656 (2011)
[3] S. Zherebtsov et al., New J. Phys. 14:075010 (2012)

A 45.4 Fri 12:00 B 302

High-n Rydberg states in strontium — •Moritz Hiller[1], Shuhei Yoshida[1], Joachim Burgdörfer[1], Shuzhen Ye[2], and F. Barry Dunning[2] — [1]Institute for Theoretical Physics, Vienna University of Technology, Austria — [2]Rice University, Houston, Texas, USA

We study the photoexcitation of strontium to high-n Rydberg states, in the presence of a weak DC electric field. The two-photon excitation process is analyzed by means of single- and two-electron models which yield marked differences in the oscillator strengths. We compare our theoretical predictions to measured data at $n \approx 300$ and analyze the observed propensity in the excitation of D states as compared to S states. A possibility to generate polarized Rydberg states is discussed.

A 45.5 Fri 12:15 B 302

Bessel beams of laser-driven two-level atoms — •Armen Hayrapetyan[1], Oliver Matula[1,2], Andrey Surzhykov[1,2], and Stephan Fritzsche[2,3] — [1]Physikalisches Institut, Universität Heidelberg, D-69120 Heidelberg, Germany — [2]Gesellschaft für Schwerionenforschung (GSI), D-64291, Darmstadt, Germany — [3]Department of Physics, P.O., Box 3000, Fin-90014 University of Oulu, Finland

We study Bessel beams of two-level atoms that are driven by the linearly polarized laser field. For such laser-driven two-level atoms, we obtain exact, Bessel-type solutions of the time-dependent Schrödinger equation that describes the dynamics of the atom-laser system beyond the typical paraxial approximation. We show that the probability density and the current of these atomic beams obtain non-trivial, Bessel-type behavior and can be tuned under the special choice of the atom and laser parameters, such as the nuclear charge, atom velocity, laser frequency and the propagation geometry of the atom and laser beams. In crossed-beam scenario, moreover, we show that both the probability density and the current of Bessel beams of different atoms acquire different time-dependency. Whereas, in collinear-beam scenario, the probability density and current of these atomic beams do not depend on time. Bessel beams of atoms are of interest to re-investigate atomic collisions, recombination processes or the generation of entanglement in atomic beams.