A 6: Atomic systems in external fields

Time: Tuesday 16:30–18:30 Location: P

A 6.1 Tue 16:30 P

Trichromatic shaper-based quantum state holography — •Kevin Eickhoff, Lea-Christin Feld, Darius Köhnke, Tim Bayer, and Matthias Wollenhaupt — Carl von Ossietzky Universität, Oldenburg, Deutschland

We present a shaper-based quantum state holography (SQuaSH) scheme based on the holographic generation of photoelectron superposition wave packets by multiphoton ionization (MPI) using pulse-shaper-generated trichromatic pump-probe-reference femtosecond pulse sequences. Differential detection of the created photoelectron wave packets enables the measurement of quantum phases imprinted in the hologram by the ionization dynamics. We implement the scheme experimentally by combining trichromatic white light shaping with velocity map imaging (VMI) of photoelectron wave packets, and investigate the MPI of potassium atoms. By interference of a probe wave packet, created by (2+1) resonance-enhanced MPI (REMPI) via the $3d$-state being two-photon resonant with the pump-pulse, and a reference wave packet from non-resonant three-photon ionization of the $4s$ ground state, we create f-type photoelectron holograms. Coherent control of the holograms by the relative optical phases of the pulse sequence is demonstrated and utilized to separate the phase-sensitive part of the hologram from the phase-insensitive background. Then we apply the scheme to determine time- and energy-dependent atomic ionization phases arising due to the time-evolution of the excited system and the detuning of the pump-pulse from the $3d$-state.

A 6.2 Tue 16:30 P

Coherent control mechanisms in bichromatic multiphoton ionization — •Lea-Christin Feld, Kevin Eickhoff, Darius Köhnke, Lars Englert, Tim Bayer, and Matthias Wollenhaupt — Carl von Ossietzky Universität, Oldenburg, Deutschland

We study two basic physical mechanisms underlying the coherent control of atomic multiphoton ionization (MPI) with bichromatic polarization-shaped femtosecond laser pulses, termed interband and intraband interference. The simultaneous measurement of energetically separated photoelectrons from both mechanisms in a single photoelectron momentum distribution (PMD) allows to compare the corresponding phase and polarization control of the angular distributions. Experimentally, we combine bichromatic polarization pulse shaping of a carrier-envelope phase-stable supercontinua with photoelectron tomography. The controllability of the PMD is investigated in three scenarios. First, counterrotating circularly polarized pulses are employed to contrast phase-insensitive angular momentum eigenstates created by intraband interference with a phase-sensitive c_7 rotationally symmetric free electron vortex (FEV) from pure interband interference. Second, orthogonal linearly polarized pulses are used to compare the phase-independence of a six-lobed angular momentum wave packet from intraband interference to the sensitivity of a complex shaped interband PMD in the presence of phase fluctuations. Finally, we demonstrate phase control of a photoelectron hologram from mixed interband interference. The azimuthal rotation of the hologram maps the time evolution of the bound state wave packet, allowing for FEV spectroscopy.

A 6.3 Tue 16:30 P

Free electron vortices meet optical vortex beams: Analogies and Differences — •Darius Köhnke[1], Kevin Eickhoff[1], Lea-Christin Feld[1], Stefanie Kerbstadt[1,2], Lars Englert[1], Tim Bayer[1], and Matthias Wollenhaupt[1] — [1]Carl von Ossietzky Universität Oldenburg, Carl-von-Ossietzky-Straße 9-11, D-26129 Oldenburg, Germany — [2]Center for Free-Electron Laser Science (CFEL), Deutsches Elektronen Synchrotron DESY, Notkestraße 85, D-22607 Hamburg, Germany

In recent years, vortex states have attracted significant interest in various fields of physics ranging from fundamental studies of light-matter interaction to advanced optical applications. Here, we present a comparative study of free electron vortices created by atomic multiphoton ionization and optical vortex beams generated with a holographic technique. On the one hand we use spectral pulse shaping to generate polarization-tailored carrier-envelope phase stable bichromatic laser pulses creating photoelectron vortices. On the other hand we employ computer generated holograms for spatial tailoring of a laser beam forming optical vortex beams. While both methods can be interpreted as an advanced double slit experiment in either the spectral or spatial domain, the resulting topological properties of the vortex states are quite different. We discuss the different topological properties as well as their manipulation. Further we demonstrate control of the symmetry and orientation of the vortex states in both scenarios.

A 6.4 Tue 16:30 P

Mass defect, time dilation and second order Doppler effect in trapped-ion optical clocks — •Victor Jose Martinez Lahuerta[1], Simon Eilers[1], Marius Schulte[1], Tanja Mehlstäubler[2], Piet Schmidt[2,3], and Klemens Hammerer[1] — [1]Institute for Theoretical Physics and Institute for Gravitational Physics (Albert-Einstein-Institute), Leibniz University Hannover — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig — [3]Institute for Quantum optics, Leibniz University Hannover, Welfengarten 1, 30167 Hannover

We derive an approximate relativistic Hamiltonian for the center of mass and internal dynamics of an electromagnetically bound, charged two-particle system in external electromagnetic and gravitational fields. This extends earlier work by Sonnleitner and Barnett and Schwartz and Giulini to hydrogen-like ions. We apply this Hamiltonian to describe the relativistic coupling of the center of mass and internal dynamics of cold ions in Paul traps, including the effects of micromotion. In this way, we are able to provide a systematic fully quantum mechanical treatment of relativistic frequency shifts and their standard deviation in atomic clocks based on trapped ions. Our approach reproduces known formulas for the second order Doppler shift, which were previously derived on the basis of semi-classical arguments. We also complement and clarify recent discussions on the role of time dilation and mass defect in ion clocks.