A 10: Atomic Systems in External Fields

Time: Tuesday 11:00–13:00 Location: F107

Invited Talk A 10.1 Tue 11:00 F107

Interaction of twisted light with a trapped atom: Interplay of electronic and motional degrees of freedom — •Anton Peshkov[1,2], Yuriy Bidasyuk[1], Richard Lange[1], Tanja Mehlstäubler[1,3], Nils Huntemann[1], Ekkehard Peik[1], and Andrey Surzhykov[1,2] — [1]Physikalisch-Technische Bundesanstalt — [2]Technische Universität Braunschweig — [3]Leibniz Universität Hannover

Twisted light modes with orbital angular momentum (OAM) show great promise for applications in atomic clocks since excitation of a trapped atom in their low-intensity center can result in significant suppression of an undesirable light shift. In such experiments, however, an accurate description of induced Rabi oscillations is complicated by the transverse atomic motion within the strongly inhomogeneous optical field of twisted light. Here, we present a theoretical model to describe the time evolution of a single atom in a twisted Laguerre-Gaussian beam, taking into account vibrational states of the atom's center-of-mass motion in a harmonic potential created by a trap. Calculations have been performed for the $4s_{1/2} \rightarrow 3d_{5/2}$ electric quadrupole (E2) transition in Ca^+ ion. An analysis based on the density matrix formalism and the Liouville-von Neumann equation shows that the atom may undergo unconventional anharmonic Rabi oscillations that are attributed to the strong coupling between vibrational levels. This effect is accompanied by the angular momentum transfer from twisted light to the atomic center-of-mass motion and becomes most pronounced when the Rabi frequency is comparable to the trapping one.

A 10.2 Tue 11:30 F107

Mirrorless lasing in sodium vapor with buffer gas — •Sushree Subhadarshinee Sahoo[1,2], Emmanuel Klinger[1,2,3], Buddhika Hondamuni[1,2], Razmik Aramyan[1,2], Arne Wickenbrock[1,2], and Dmitry Budker[1,2,4] — [1]Johannes Gutenberg-Universität, 55128 Mainz, Germany — [2]Helmholtz-Institut Mainz, GSI Helmholtzzentrum für Schwerionenforschung, 55128 Mainz, Germany — [3]FEMTO-ST, UMR CNRS 6174, Université Bourgogne Franche-Comté, 25030 Besançon, France — [4]Department of Physics, University of California, Berkeley, California 94720, USA

The study of mirrorless lasing in sodium vapor has been of great interest in recent years because of its potential application in remote sensing of magnetic fields in the mesosphere. Mirrorless lasing is achieved by exciting the sodium atoms with resonant laser light at 589 and 569 nm by two-photon transition, which leads to the generation of directional infrared light. The use of this phenomenon on-sky measurements necessitates simulating the atmospheric conditions of the mesosphere in a laboratory. Hence, in this work, We investigate the effect of buffer gas on mirrorless lasing in sodium vapor. We observe that the generation amplitude of the mirrorless lasing increases with the increasing pressure of the buffer gas while there is a higher lasing threshold in the optical power as well as the number density of atoms. This study suggests that mirrorless lasing can indeed be generated in the upper atmosphere.

A 10.3 Tue 11:45 F107

Generating a focal field dominated by an arbitrary multipole component in 4Pi optical systems — •Yuxiong Duan[2], Markus Sondermann[1,2], and Gerd Leuchs[1,2] — [1]Institute of Optics, Information and Photonics, Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen, Germany — [2]Max Planck Institute for the Science of Light, 91058 Erlangen, Germany

Selective multipole excitation is of great interest in laser spectroscopy of atoms and nano-particles [1,2]. In particular, tailored excitation fields have been utilized for addressing individual multipole resonances while suppressing others. However, almost without exception, the light fields that have been applied contain numerous multipole components [3]. In contrast, here we establish a theoretical framework for shaping a focal field which is dominated by only the target multipole. This is possible in 4Pi optical systems. We derive analytically the angular spectrum of pure multipoles. Taking an ideal parabolic mirror as an example, we demonstrate how to determine the matching incident beam through a mathematical relation to the angular spectrum of the target multipole. Moreover, geometric factors including the limited system size and the orientation of the quantization axis of the target multipole have been investigated. Our results indicate that the generated field can be applied for maximizing the selective multipole excitation strength and enriching laser spectroscopy with high controllability.

[1] C. T. Schmiegelow, et al, Nat. Commun. 7, 1-6 (2016).
[2] P. Woźniak, et al, Laser Photonics Rev. 9, 231-240 (2015).
[3] R. Maiwald, et al, Nat. Phys. 5, 551-554 (2009).

A 10.4 Tue 12:00 F107

Towards Driving Quantum Systems with the Non-Radiating Near-Field of a Modulated Electron Beam — •Thomas Weigner[1], Matthias Kolb[1], Thomas Spielauer[1], Johann Toyfl[1], Giovanni Boero[2], and Philipp Haslinger[1] — [1]VCQ, Technische Universität Wien, Atominstitut Stadionallee 2, 1020 Vienna, Austria — [2]EPFL, BM 3110 Station 17, CH-1015 Lausanne, Switzerland

Coherent manipulation of quantum systems generally relies on electromagnetic radiation as produced by lasers or microwave sources. In the experiment presented here we attempt a novel approach to drive quantum systems, as it was recently proposed (D. Rätzel, D. Hartley, O. Schwartz, P. Haslinger, A Quantum Klystron - Controlling Quantum Systems with Modulated Electron Beams. Phys. Rev. Research 3, 023247, 2021).

This method utilizes the non-radiating near-field of a modulated electron beam to coherently drive quantum systems, leading to new possibilities for controlling quantum states. For instance, one can locally address subsystems far below the diffraction limit of electromagnetic radiation or paint potentials at atomic scales.

In this proof of concept experiment, we want to couple the oscillating near-field of a spatially modulated electron beam to the unpaired spins of a solid, organic radical sample (BDPA) or the hyperfine levels of laser cooled Potassium atoms. The electron beam is generated with a cathodic ray tube from a fast analog oscilloscope.

A 10.5 Tue 12:15 F107

The Auger electron knows if the photoelectron met another atom — •Andreas Hans[1], Niklas Golchert[1], Emilia Heikura[1], Nils Kiefer[1], Lutz Marder[1], Catmarna Küstner-Wetekam[1], Johannes Viehmann[1], Jerome Palaudoux[2], Francis Penent[2], and Arno Ehresmann[1] — [1]Institut für Physik und CINSaT, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany — [2]Sorbonné Universite, CNRS, Laboratoire de Chimie Physique-Matière et Rayonnement, LCPMR, F-75005 Paris Cedex 05, France

Auger spectroscopy is a powerful and omnipresent method in both fundamental research and applied science. Generally, in a two-step model the Auger process is regarded to be independent from the initial photoionization event. Only for very low excess energies of the photoelectron, the electrons need to be considered to be correlated through the so-called post collision interaction (PCI). Here we demonstrate that this picture fails if an atom is located in an environment the photoelectron can interact with. In particular, a Coulomb contribution needs to be subtracted from the Auger electron's kinetic energy if the photoelectron created charged atoms nearby by electron-impact ionization.

A 10.6 Tue 12:30 F107

Relativistic strong-field ionization of hydrogen-like atomic systems in constant crossed electromagnetic fields — •Alexandra Eckey[1], Michael Klaiber[2], Alexander B. Voitkiv[1], and Carsten Müller[1] — [1]Heinrich-Heine-Universität Düsseldorf, Germany — [2]Lochhofstraße 8, 78120 Furtwangen, Germany

We study relativistic strong-field ionization of hydrogen-like atoms or ions in a constant crossed electromagnetic field by formulating the transition amplitude within the strong-field approximation in the Goeppert-Mayer gauge, with initial and final electron states being described by the corresponding Dirac-Coulomb and Dirac-Volkov wave functions, respectively. By adapting an established method, Coulomb corrections to the electron motion during tunneling are included. We calculate total and energy-differential ionization rates in a wide range of atomic numbers and applied field strengths and compare them with predictions from other theories.

A 10.7 Tue 12:45 F107

Majorana Zero Modes in Fermionic Wires coupled by Aharonov-Bohm Cages — •Niklas Tausendpfund[1,2], Sebastian Diehl[2], and Matteo Rizzi[1,2] — [1]Peter Grünberg Institut 8, Forschungszentrum Jülich, Germany — [2]Institute for Theoretical Physics, University of Cologne, Germany

We devise a number-conserving scheme for the realization of Majorana Zero Modes in an interacting fermionic ladder coupled by Aharonov-Bohm cages. The latter provide an efficient mechanism to cancel single-particle hopping by destructive interference. The crucial parity symmetry in each wire is thus encoded in the geometry of the setup, in particular, its translation invariance. A generic nearest-neighbor interaction generates the desired correlated hopping of pairs. We exhibit the presence of an extended topological region in parameter space, first in a simplified effective model via bosonization techniques, and subsequently in a larger parameter regime with matrix-product-states numerical simulations. We demonstrate the adiabatic connection to previous models, including exactly-solvable ones, and we briefly comment on possible experimental realizations in synthetic quantum platforms, like cold atomic samples.