A 5: Atomic systems in external fields

Time: Monday 14:30–16:30 Location: C/kHS

A 5.1 Mon 14:30 C/kHS

Generalized Spin Precession Equations — •Hans-Jürgen Stöckmann[1] and Dirk Dubbers[2] — [1]Fachbereich Physik der Philipps-Universität Marburg, Renthof 5, 35032 Marburg, Germany — [2]Physikalisches Institut der Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

The Bloch equations, which describe spin precession and relaxation in external magnetic fields, can be generalized to include the evolution of polarization tensors of various ranks in arbitrary multipole fields [1]. We show applications of the generalized spin precession equations with simple examples from atomic, nuclear, and condensed matter physics, and compare the various approaches to the problem found in the literature. The derivation of the generalized Bloch equations can be considerably simplified by using a particular bra-ket notation for irreducible tensors.

[1] H.-J. Stöckmann, D. Dubbers, New J. of Phys. 16, 053050 (2014)

A 5.2 Mon 14:45 C/kHS

The effect of bound state dressing on laser assisted radiative recombination — •Robert A. Müller[1,2], Andrey Surzhykov[2], Daniel Seipt[2], and Stephan Fritzsche[1,2] — [1]Friedrich-Schiller-University Jena, Germany — [2]Helmholtz-Institute Jena, Germany

Radiative recombination is the capture of a continuum-state electron into a bound state of an ion, accompanied by the emission of a photon. If the system is exposed to an external laser field the process is commonly called *laser assisted radiative recombination* (LARR). LARR is mainly discussed as a part of the so called *three step model* in high harmonic generation and as a process to stimulate the formation of antihydrogen [1]. During the recent years a number of theoretical studies have been performed aiming for an analytical description of the laser assisted capture of an electron [2]. In most of these works either (i) the interaction between the continuum electron and the nucleus or (ii) the laser dressing of the bound state is neglected. In this contribution, therefore, we present a theoretical study of laser assisted radiative recombination accounting for both effects in an approximate way. Calculations are performed for bare low-Z ions and optical laser fields up to 10^{14}W/cm^2. Based on our calculations we found that the dressing of the bound state introduces additional asymmetries in the spectrum of the emitted photons. Moreover we could show that differences in the total cross section of LARR and the laser free process can be explained by the pertubation of the ionic wave function.

[1] D.B. Milošević and F. Ehlotzky, Phys. Rev. A **65**, 042504 (2002)
[2] G. Shchedrin and A. Volberg, J. Phys. A **44**, 245301 (2011)

A 5.3 Mon 15:00 C/kHS

^{3}He magnetometer for extreme precision measurement of high magnetic field — •Andreas Maul[1], Anna Nikiel[1], Peter Blümler[1], Werner Heil[1], Ernst Otten[1], Sergej Karpuk[2], Manfred Hehn[3], Laura Schreiber[4], and Maxim Terekhov[4] — [1]Institute of Physics, Johannes Gutenberg-Universität Mainz — [2]Institute for Nuclear Chemistry, Johannes Gutenberg-Universität Mainz — [3]MPI for Polymer Research, Mainz — [4]University Medical Center Mainz

Precise measurements and monitoring of high magnetic field are required for instance in high resolution mass spectroscopy using Penning traps or in the g-2 muon experiment. Our approach uses nuclear magnetic resonance detection on gaseous, nuclear spin-polarized ^{3}He. The nuclei of the ^{3}He gas are spin-polarized in-situ using a new, non-standard variant of the Metastability Exchange Optical Pumping (MEOP). The essential point is that coherent spin-precession times (T_2^*) of several minutes can be obtained in fields of > 1 Tesla [1]. From the measured Larmor frequency the local magnetic field can be determined with an relative accuracy better than 10^{-12}. Such a device can be miniaturized to fit next to a Penning trap in order to monitor and determine magnetic fields even at low temperatures and ultrahigh vacuum conditions. The current status and first results of the experiment will be presented.

[1] A. Nikiel, P.Blümler, W.Heil, M.Hehn, S.Karpuk, A.Maul, E.Otten, L.M.Schreiber, and M.Terekhov, Eur. Phys. J. D, 68 (2014), 330

A 5.4 Mon 15:15 C/kHS

Controlling the magnetic-field sensitivity of atomic-clock states by microwave dressing — •Lörinc Sárkány, Helge Hattermann, and József Fortágh — CQ Center for Collective Quantum Phenomena and their Applications, Physikalisches Institut, Eberhard Karls Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

The sensitivity of atomic transitions to external field perturbations represents a major limitation for the accuracy and stability of atomic clocks and for the time of quantum-information storage in ultracold atoms and atomic gases. Electromagnetic field fluctuations and inhomogeneous trapping potentials give rise to temporal and spatial variations of atomic transition frequency.

We demonstrate control of the differential Zeeman shift between clock states of ultracold rubidium atoms by means of nonresonant microwave dressing. By dressing the state pair $5S_{1/2}F = 1, m_F = -1$ and $F = 2, m_F = 1$, a residual frequency spread of <0.1 Hz in a range of 100 mG around a chosen magnetic offset field can be achieved [1]. We further identify *double magic* points, around which the clock frequency is insensitive to fluctuations both in the magnetic field and the dressing Rabi frequency. The technique is compatible with chip-based cold atom systems and allows the creation of clock and qubit states with reduced sensitivity to magnetic field noise.

[1] L. Sárkány *et al.*, Phys. Rev. A **90**, 053416 (2014)

A 5.5 Mon 15:30 C/kHS

Strong-field ionization with semi-classical trajectories: the role of the initial conditions — •Thomas Keil and Dieter Bauer — Universität Rostock, Institut für Physik

Photoelectron spectra for atoms in 7 μm laser fields [1] are calculated using so-called 'quantum orbits'. In the semi-classical limit, the method is known to yield good results in atomic [1-3] and cluster [4] ionization (see [5] for a review). Moreover, it is computationally less demanding than corresponding TDSE calculations, especially for very long laser wavelengths and high intensities where the ab initio solution of the TDSE is expensive, if not prohibitive. In this work, we analyze trajectory-based Coulomb-corrected strong-field approximation (CCSFA) calculations for momentum-resolved photoelectron spectra with respect to the influence of the choices for (i) the ionization rate and (ii) the initial conditions (i.e., momentum and tunnel exit).

[1] Y. Huismans, Science 331, 61 (2011)
[2] T.-M. Yan et al., Phys. Rev. Lett. 105, 253002 (2010)
[3] T.-M. Yan et al., Springer Series in Chem. Phys. vol. 104 (2013)
[4] Th. Keil et al., J. Phys. B 47, 124029 (2014)
[5] S.V. Popruzhenko, J. Phys. B 47 204001 (2014).

A 5.6 Mon 15:45 C/kHS

Exciton-phonon coupling in external fields — •Frank Schweiner, Jörg Main, and Günter Wunner — 1. Institut für Theoretische Physik, 70550 Stuttgart, Germany

Starting from the most simple description of an exciton as being a hydrogen-like system we construct an interaction Hamiltonian in first quantization, which describes a coupling of the exciton to acoustic and optical phonons. This is done using the descriptions of deformation potential coupling and Fröhlich interaction already known from electron-phonon interaction. By numerical investigation of the coupled system we try to reproduce a broadening of the lines of the hydrogen-like spectrum, which has recently been observed in experiments of the group of Fröhlich on cuprous oxide for quantum numbers up to n=25 (T. Kazimierczuk, Nature 514, 343, 2014). A further inclusion of external electric and magnetic fields shall prove the existence of exceptional points in the spectra.

A 5.7 Mon 16:00 C/kHS

Charge-resolved ion energy spectra of cluster coulomb explosion — •Dzmitry Komar, Josef Tiggesbäumker, and Karl-Heinz Meiwes-Broer — Universität Rostock, Institut für Physik, Universitätsplatz 3, D-18051 Rostock

Small silver metal particles of about 2000 atoms are produced by a magnetron sputtering gas aggregation cluster source. Directly in front of the nozzle the clusters are exposed to intense 100 fs dual pulses of about 10^13-10^14 W/cm^2. For the analysis of the charge-resolved ion energy spectra a modified Thomson parabola spectrometer is used.

The new design features an improved energy resolution and a higher transmission compared to other setups. Optical delay studies show the impact of nanoplasmonic oscillations on the ion charge states as well as the recoil energies. Under optimized conditions charge states of up to q=19 and recoil energies of 300 keV are observed at moderate laser intensities. The results on the ions agree well with our recent studies on the electron emission under comparable conditions [1]. In particular at the Mie resonance the highly charged ions are predominantly emitted along the laser polarization axis.

[1] J. Passig, R. Irsig, N. X. Truong, T. Fennel, J. Tiggesbäumker, and K. H. Meiwes-Broer, New J. Phys. 14, 085020 (2012).

A 5.8 Mon 16:15 C/kHS

Evolution of very low energy states crossing the ionization threshold in strong mid-infrared fields — •Benjamin Wolter[1], Christoph Lemell[2], Matthias Baudisch[1], Michael G. Pullen[1], Xiao-Min Tong[3], Arne Senftleben[4], Claus Dieter Schröter[5], Joachim Ullrich[5,6], Robert Moshammer[5], Joachim Burgdörfer[2], and Jens Biegert[1,7] — [1]ICFO - Institut de Ciències Fotòniques, Mediterranean Technology Park, Castelldefels (Barcelona), Spain — [2]Institute for Theoretical Physics, Vienna University of Technology, Vienna, Austria — [3]Center for Computational Sciences, University of Tsukuba, Ibaraki, Japan — [4]Universität Kassel, Institut für Physik and CINSaT, Kassel, Germany — [5]Max - Planck - Institut für Kernphysik, Heidelberg, Germany — [6]Physikalisch - Technische Bundesanstalt, Braunschweig, Germany — [7]ICREA - Institució Catalana de Recerca i Estudis Avançats, Barcelona, Spain

Intense long wavelength ($\lambda \geq 2\,\mu$m) laser pulses enable experiments in the tunneling ionization regime ($\gamma \ll 1$) and reveal surprising low electron energy features, which can not be described with the strong-field approximation (SFA). These features, universal for all target species, include the low-energy structure (LES), the very-low-energy structure (VLES) and the zero-energy structure (ZES). Using full 3D electron-ion coincidence detection in combination with our ultrafast 160 kHz mid-IR source, we reveal the entire 3D momentum spectrum well below 1 eV. Quantum and classical simulations allow for an interpretation of the LES, VLES and of the newly identified ZES.