A 50: Atomic systems in external fields II

Time: Friday 14:00–15:45 Location: B 302

A 50.1 Fri 14:00 B 302

Ultra-long-range Rydberg molecules exposed to external electric fields — •Markus Kurz[1], Michael Mayle[2], and Peter Schmelcher[1] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg — [2]JILA, University of Colorado and National Institute of Standards and Technology, Boulder, Colorado 80309-0440, USA

We investigate the impact of an external electric field on ultra-long-range Rydberg molecules in the ultra-cold regime. The theoretical framework of the considered problem is based on the Fermi pseudopotential approximation, where we include p-wave contributions in the electron-perturber interaction. Hereafter, we study the rich topology of the Born-Oppenheimer potential surfaces for several field strengths. Furthermore, we analyze the rovibrational dynamics for different electronically excited states. Finally, we present a preparation scheme for high-ℓ molecular electronic states via a two photon excitation process.

A 50.2 Fri 14:15 B 302

Measurements of the dynamic and Berry phases in Rb superposition states — •Carl Basler — Department of Molecular and Optical Physics, Universität Freiburg

We study the transient response of the refractive index to changes of the magnetic field vector under conditions of electromagnetically-induced transparency. This is an extension of our recent work, FM et al. PR A 85, 013820 (2012) where the dynamic response to frequency changes was explored. Under EIT conditions the superposition state $\Psi = (|1\rangle - e^{i\eta}|2\rangle)/\sqrt{2}$ is called dark state and is barred from fluorescence. This state develops by spontaneous emission in the presence of two phase-stable laser fields $E_j(\omega_j, \phi_j)$. The dark state phase fulfils the requirement $\eta = \phi_1 - \phi_2$ and is thus sensitive to the laser phases. When the dark state has formed and the lasers are suddenly detuned from EIT resonance the atoms undergo Rabi floppings between dark and bright state.

When changing the magnetic field, the lasers are also detuned from resonance due to Zeeman shifts and the dark state atoms pick up a dynamic phase. When the magnetic field is not changed in strength but rotated in space the system acquires a Berry phase. We show measurements of the dynamic phase and the Berry phase of Rb-atoms in a buffered gas cell at room temperature.

A 50.3 Fri 14:30 B 302

Doppler-free Magnetically Induced Dichroism Signals of the deep UV 6^1S_0 - 6^3P_1 Transition in Neutral Mercury Atoms — •Martin Fertl — Paul Scherrer Institut, Villigen, Switzerland — on behalf of the nEDM Collaboration: nedm.web.psi.ch

We report on the observation of Doppler-free magnetically induced dichroism signals of the deep UV 6^1S_0 - 6^3P_1 transition in neutral mercury atoms of all naturally abundant isotopes. The signals are used to frequency stabilize a UV frequency-quadrupled diode laser system (FHG) to sub-MHz stability without frequency modulation and with sub-mW light power (sub-Doppler DAVLL). The FHG is part of a free induction decay magnetometer based on spin polarized ^{199}Hg atoms. Polarized ^{199}Hg atoms precess freely in a magnetic field after a $\pi/2$ flip. This precession is detected as amplitude modulation of a circularly polarized UV light beam traversing the Hg storage volume in the spin precession plane (ODMR). Present techniques, using off-resonant light (e.g. ^{204}Hg discharge lamp) can induce vector light shifts and induce systematic frequency shifts. The FHG will be locked to the frequency where this vector light shift effect is absent. The magnetometer is employed to extract and survey the time stability ($\approx 10^{-8}$ over 100s) of the magnetic field ($\approx 1\mu$T) in the neutron electric dipole moment (nEDM) experiment at the Paul Scherrer Institute, Switzerland (PSI). The frequency locking scheme might also be applied to laser cooling of mercury atoms for magneto optical traps. This project is supported by the Swiss National Science Foundation under contract number 200021-126562.

A 50.4 Fri 14:45 B 302

Nuclear recollisions in laser-assisted α decay — •Héctor Mauricio Castañeda Cortés[1], Carsten Müller[1,2], Christoph H. Keitel[1], and Adriana Pálffy[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf

Laser-driven recollisions have come to play a crucial part in atomic strong-field physics. In this work we investigate theoretically the nuclear physics counterpart involving a repulsive potential, namely laser-driven recollisions following α decay. The effects of the intense laser field on the α particle tunneling and dynamics after emission were accounted for in the framework of a laser-assisted decay of quasistationary states formalism [1]. We find that under the action of a strong laser field, the α particle may change its trajectory after emission and be driven back to recollide with the daughter nucleus at energies sufficient to produce nuclear reactions and on time scales currently not available in experiments [2]. Fast recollisions can even allow probing short-lived excited nuclear states reached via α decay. Thus, laser-driven nuclear recollisions open the exciting possibility to investigate a new energy regime at the interplay between the electromagnetic and strong forces. We show here that such recollisions are rare but detectable already at presently available laser intensities of $10^{22} - 10^{23}$ W/cm^2 [2].

[1] H. M. Castañeda Cortés, S. V. Popruzhenko, D. Bauer and A. Pálffy, New J. Phys. 13, 063007 (2011).
[2] H. M. Castañeda Cortés, C. Müller, C. H. Keitel and A. Pálffy, arXiv:1207.2395

A 50.5 Fri 15:00 B 302

Recent Improvements of a mobile polarizer system for ^{129}Xe — •Vanessa Stahl[1], Werner Heil[1], Sergei Karpuk[1], Peter Blümler[1], Maricel Repetto[1], Benjamin Niederländer[1], Manuel Braun[1], Martin Fuchs[1], Kerstin Münnemann[2], and Hans Spiess[2] — [1]Institut für Physik, Universität Mainz — [2]Max Planck Institute for Polymer Research Mainz

(HP) ^{129}Xe has numerous applications both in fundamental physics like nuclear spin clocks [1] and in medical research, e.g. in lung MRI [2,3]. We report on a compact mobile ^{129}Xe polarizer built in order to achieve high polarization degrees operating in counter flow. The optical pumping scheme is optimized in terms of magnetic field homogeneity, rubidium saturation, freeze-thaw method [4], gas-transport and its storage in special vessels with low wall relaxation. This talk will cover different aspects of HP gas production, manipulation and minimization of losses due to relaxation.

[1] C. Gemmel, Phys. Rev. D 82, 111901(R) (2010)
[2] Driehuys, Radiology 262, 1 (2012)
[3] H. E. Möller, Jour. of Magn. Res. in Med. 41, 1058-1064 (1999)
[4] I. C. Ruset and F.W. Hersman, PRL 96, 053002 (2006)

A 50.6 Fri 15:15 B 302

Spin dynamics in the relativistic Kapitza-Dirac effect — •Sven Ahrens[1], Heiko Bauke[1], Christoph H. Keitel[1], and Carsten Müller[1,2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf

The Kapitza-Dirac effect [1], which is the diffraction of electrons at a standing wave of light, has been observed experimentally in the last decade [2]. The availability of novel high intensity X-ray laser sources calls for a relativistic description of this electron scattering process.

We discuss the quantum dynamics of the electron diffraction by solving the Dirac equation in momentum space [3]. We demonstrate that generalized 3-photon Kapitza-Dirac scattering of the electron with the laser beam occurs if the energy and the momentum of corresponding classical kinematics are conserved. This 3-photon Kapitza-Dirac effect features a tunable electron spin-flip probability. We emphasize the significance of the electron's spin-degree of freedom by a comparison with corresponding quantum dynamics of the Klein-Gordon equation.

[1] P. L. Kapitza, P. A. M. Dirac, Proc. Cambridge Philos. Soc. **29**, 297–300 (1933)
[2] D. L. Freimund, K. Aflatooni, H. Batelaan, Nature **413**, 142–143 (2001)
[3] S. Ahrens, H. Bauke, C. H. Keitel, C. Müller, Phys. Rev. Lett. **109**, 043601 (2012)

A 50.7 Fri 15:30 B 302

Angular distribution effects in multi-photon ionization — •Gregor Hartmann[1,2], Markus Braune[3], Toralf Lischke[1,2], André Meissner[1], André Knie[4], Arno Ehresmann[4], Markus Ilchen[3], Omar Al-Dossary[5,6], and Uwe Becker[1,2,5] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany — [2]Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle, Germany — [3]DESY Notkestraße 85, 22067 Hamburg, Germany — [4]Institut für Physik and CINSaT, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany — [5]Physics Department, College of Science, King Saud University, Riyadh 11451, Saudi Arabia — [6]National Center for Mathematics and Physics, KACST, Saudi Arabia

The angular distribution of emitted photoelectrons is determined by the transfer of the angular momentum of the ionizing photon to the ejected electron. In the case of two-photon ionization another angular momentum of one comes into play giving rise to a Legendre polynomial of fourth order, the so called β_4 term. Interestingly this additional term does not only effect the electrons emitted by two photons but also the one being ejected by one photon only. This shows that both processes are coherently coupled. We show this effect for the first time for the two-photon ionization of the rare gases measured at FLASH. Even more interesting is the fact that this phenomenon is even observed for the case of He although 1s-shell photoionization should exhibit no β_4 term at all because the remaining hole is isotropic. We interpret this unexpected result as due to autoionizing doubly excited resonances in He.