A 21: Atomic systems in external fields II

Time: Thursday 14:00–16:00 Location: BAR 205

A 21.1 Thu 14:00 BAR 205

Development of a Magnetically Shielded Compact ^{3}He Polarizer — •Oliver Endner, Christopher Hauke, Werner Heil, Sergei Karpuk, Jan Klemmer, Christian Mrozik, and Ernst-Wilhelm Otten — Institut für Physik, Johannes Gutenberg-Universität, Mainz

The method of polarizing ^{3}He via metastability exchange optical pumping is well known since the early 1960s. Since then hyperpolarized gases have found manifold applications in fundamental science as well as in medical research. The present polarizer apparatus in Mainz used as central facility is well established and can produce up to three standard liters of gas per hour with a polarization of 60–65 %, sufficient for medical applications. For basic research where higher degrees of polarization are needed one can reach up to 78 % at a production rate of one standard liter per hour. To provide the users with high polarization degrees and big amounts of polarized gas a compact apparatus was designed. Using this compact polarizer as local polarizing facility enables the users to avoid polarization losses during shipping. For the new polarizer several concepts had to be developed to minimize the size while retaining the production rate and polarization degree. There have been efforts in optimizing optics, polarization conserving compression of the gas and homogenization of the magnetic field. By using a closed cylinder of soft magnetic material a relative field gradient of better than $\Delta B/B < 3.8 \cdot 10^{-4}\,\mathrm{cm}^{-1}$ has been obtained, which is needed to have the desired gradient relaxation time for sufficient polarization. Further results will be presented in this talk.

A 21.2 Thu 14:15 BAR 205

Long-lived resonance states in planar helium — Celsus Bouri[1,2], Johannes Eiglsperger[3], Javier Madronero[3,4], Felix Joerder[1], •Pierre Lugan[1], Vera Neimanns[1], Klaus Zimmermann[1], and Andreas Buchleitner[1] — [1]Physics Department, University of Freiburg, Germany — [2]CEPAMOQ, Universite de Douala, Cameroon — [3]Physics Department, TU Munich, Germany — [4]PAMO, Universite catholique de Louvain, Louvain la Neuve, Belgium

Doubly excited states of helium ionize because of the Coulomb interaction between the two electrons of the atom and the formation of resonance states. Long-lived resonance states have been identified in the form of so called frozen planet states [1], i.e. collinear configurations of the electrons and the nucleus, with zero angular momentum, which exhibit a remarkable stability. We report here on the identification of analogous long-lived resonance states for non-vanishing angular momentum, and on the characterization of electronic correlations in these states. The ionization of the latter is analyzed on the basis of partial decay rates extracted from complex dilation.

[1] K. Richter and D. Wintgen, J. Phys. B 23, L197 (1990).

A 21.3 Thu 14:30 BAR 205

Single Atom Interferometer with Spatial Separation — •Andreas Steffen, Noomen Belmechri, Michal Karski, Kohei Katayama, Sebastian Hild, Andrea Alberti, Wolfgang Alt, Artur Widera, and Dieter Meschede — Institut für angewandte Physik, Universität Bonn

We demonstrate a single atom interferometer (SAI) consisting of a Cs atom being split by multiple sites in a 1D optical lattice. State-dependent dipole potentials controlled by the lattice polarization allow coherent division and recombination over up to 11 sites. The two spatially separated states of the SAI accumulate phase from spatial potential differences, making the SAI sensitive to magnetic field gradients or acceleration. We have characterized the phase stability of the interferometer and its sensitivity to potential gradients. In the future, collisional phases and two-atom entanglement shall be measured using this setup.

A 21.4 Thu 14:45 BAR 205

Numerical solution of coupled radial ODE eigenvalue problems — •Robert Hammerling[1] and Othmar Koch[2] — [1]Center Computational Material Science, TU Wien, A-1040, AUT — [2]Institute for Analysis, TU Wien, A-1040, AUT

In the effective one-particle description of electronic structure within DFT one has to calculate eigenvalues of PDE Schrödinger operators. For deep lying core states normally only the local radial potential is used and therefore decoupled ODEs can be solved. In this contribution we present our non-perturbative approach (see e.g. Computer Physics Communications, 181, 1557) to the coupled radial equations in a non-spherical potential. We compare a few different solution methods, one-sided matrix shooting, two-sided matrix shooting, polynomial collocation strategies and basis set expansion methods. The studied test cases comprise the Hydrogen molecular ion treated in one-center approximation and the dc-Stark effect of the Hydrogen atom.

The work is part of a joint collaboration between mathematicians and physicists within the project 'Mathematik und .. 2007' sponsored by WWTF.

A 21.5 Thu 15:00 BAR 205

3D ground state cooling in a doughnut-shaped optical trap — •Sebastian Hild, Andrea Alberti, Wolfgang Alt, Noomen Belmechri, Michal Karski, Kohei Katayama, Arif Mawardi, Andreas Steffen, Artur Widera, and Dieter Meschede — Institut für Angewandte Physik der Universität Bonn, Germany

We report on our approach to 3D ground state cooling in a state-selective 1D optical lattice potential, paving the way to create entanglement via controlled cold collisions. Due to weak transversal confinement in the 1D standing wave the Lamb-Dicke regime can only be reached in the axial direction. By superposing a blue detuned doughnut shaped beam, the trap frequencies in the radial direction can be increased significantly. Raman lasers will then be used to reach the vibrational ground state. This will also allow us to prepare Cs atoms in their motional ground state. Increased coherence times open the perspective to extend the prior work, such as quantum walks, to new regimes of unprecented quantum control over single neutral atoms.

A 21.6 Thu 15:15 BAR 205

Nuclear spin-dependent parity-violation asymmetry in hyperfine transitions in He-like ions — •Fabrizio Ferro[1,2], Andrey Surzhykov[1,2], and Thomas Stöhlker[1,2,3] — [1]Physikalisches Institut, Universität Heidelberg, Germany — [2]GSI-Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany — [3]Helmholtz-Institut Jena, Germany

Parity-violation (PV) in atomic systems offers a unique possibility to test the electroweak theory at very low energies. In atoms with non-zero nuclear spin, $I \neq 0$, the nuclear parity-violating anapole moment interacts magnetically with electrons. This leads to the appearance of parity-forbidden electromagnetic transitions between atomic levels. Recent efforts have been targeted at measuring the anapole moment in neutral atoms. Instead, we propose an alternative way, by employing He-like ions as available at storage ring facilities (e.g. ESR-GSI), and taking advantage of the precision spectroscopy techniques available for highly-charged ions. We show that by stimulating the transition between the hyperfine levels $(1s2s)\,^1S_0$ $(F = I)$ and $(1s2s)\,^3S_1$ $(F' = I-1, I, I+1)$ with circularly-polarized laser light, an interference term between the allowed M1 multipole and the E1 parity-violating multipole may be observed in the cross section. By performing this experiment with ions in the range $28 \leq Z \leq 35$ alternatively with left- and right-polarized light, an asymmetry of order 10^{-7} in the cross section is expected. In the last part of the talk, we discuss the key experimental requirements for such a measurement, and show how the asymmetry directly relates to the nuclear weak charge.

A 21.7 Thu 15:30 BAR 205

Quantum simulations of coupled electronic and nuclear fluxes in molecules — •Anatole Kenfack[1], Ingo Barth[2], Hans-Christian Hege[3], Michael Koppitz[3], Caroline Lasser[4], Joern Manz[1], Falko Marquardt[3], Guennadi Paramonov[1], and Beate Paulus[1] — [1]Institut für Chemie und Biochemie, FU Berlin, Takustr.3, 14195 Berlin — [2]Max-Born Institut, Max-Born-Str. 2A, 12489 Berlin — [3]Zuse Institut Berlin, Takustr.7, 14195 Berlin — [4]Zentrum Mathematik, TU München, 85747 Garching

To compute electronic and the nuclear fluxes in molecules, a Born-Oppenheimer (BO) based method has recently been developed [1]. This approach is promising for large molecules since the non-BO is restricted to 3-body problem[2,3]. For a vibrating H_2^+, novel effects have been discovered. As an example, there are attoseconds intervals where the electron does not adapt to the nuclear motion. The visualization of the associated densities and fluxes supports the present analysis. The initial state preparation also matters and yields significant deviations[4]. Interesting departures have been revealed with isotopes of H_2^+: the heavier the isotope, the larger the flux, the smaller the dispersion, and the longer the revival period. These results are partly explained analytically. The mechanism of few observables remains subtle as the result of quantum interference [5]. [1] I. Barth et al. CPL 481, 118 (2009). [2] Chelkowsky et al. PRA 52, 2977 (1995) [3] F. Martin et al. Science 315, 629 (2007) [4] A. Kenfack et al. PRA 81, 052502 (2010) [5] A. Kenfack et al. (2010), PRA (2010) in press.

A 21.8 Thu 15:45 BAR 205

Partial Decay Rates in Driven One Dimensional Helium — Celsus Bouri[1,2], Felix Jörder[1], Pierre Lugan[1], Vera Neimanns[1], Sören Roerden[1], •Klaus Zimmermann[1], and Andreas Buchleitner[1] — [1]Albert-Ludwigs University of Freiburg — [2]University of Douala, Cameroon

The continous part of the spectrum of one dimensional driven Helium below the double ionization threshold is structured by resonances, that play a vital role in its decay.

We employ the method of complex dilation to resolve the decay from a given initial state into channels, distinguishing between single and double ionization. By means of Floquet theory we tell processes with different numbers of photons involved apart.