A 27: Ultra-Cold Atoms, Ions and BEC III (with Q)

Zeit: Donnerstag 14:00–16:00 Raum: VMP 6 HS-C

Hauptvortrag A 27.1 Do 14:00 VMP 6 HS-C
Quantum gases of ultracold polar molecules — •Silke Ospelkaus — JILA, NIST and University of Colorado, Boulder, CO, USA

Polar molecules, molecules exhibiting a permanent electric dipole moment, have bright perspectives as systems with long-range and anisotropic interactions. These interactions form the basis for numerous exciting theoretical proposals ranging from ultra-cold chemistry, precision measurements, quantum phase transitions, to novel systems for quantum information processing and quantum control with external magnetic and electric fields. We will present our recent work on the creation and characterization of a near quantum degenerate gas of rovibrational ground state polar $^{40}K^{87}Rb$ molecules. Using a single step of two photon coherent transfer, we convert weakly bound KRb Feshbach molecules to the rovibrational ground state of the singlet electronic ground molecular potential. The polar molecules have a permanent electric dipole moment, which we measure with Stark spectroscopy to be 0.566(17) Debye.

Work done in collaboration with K.-K. Ni, M. H. G. de Miranda, A. Peer, B. Neyenhuis, J. J. Zirbel, P. S. Julienne, S. Kotochigova, D. S. Jin and J. Ye

Fachvortrag A 27.2 Do 14:30 VMP 6 HS-C
Quantum Gases under Electron Bombardment — •Herwig Ott, Tatjana Gericke, Peter Würtz, Tim Langen, and Andreas Koglbauer — Institut für Physik, Johannes Gutenberg-Universität, Mainz

Scanning electron microscopy is routinely used to study solid objects on a nanometer scale. Applied to ultracold quantum gases it constitutes a powerful imaging and manipulation technique that combines single atom sensitivity with high spatial resolution.

We have adapted a scanning electron microscope for the study of Bose-Einstein condensates of rubidium atoms. The focussed electron beam ionizes the atoms which are subsequently detected. Loading the condensate in a two-dimensional optical lattice with 600 nm period we demonstrate single site addressability and show that one can produce arbitrary patterns of occupied lattice sites. Such micro-engineered quantum gases might become an important resource for future applications in quantum simulation and quantum information processing.

Ultimately, we want to employ this technique to make snapshots of the many-body wave function and to get *in situ* access to the quantum correlations of bulk, lattice and low-dimensional quantum systems.

A 27.3 Do 15:00 VMP 6 HS-C
Trap assisted creation of giant molecules and Rydberg-mediated coherent charge transfer in a Penning trap — •Igor Lesanovsky[1,2], Markus Müller[1], and Peter Zoller[1] — [1]Institute for Theoretical Physics, University of Innsbruck, and Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, Innsbruck, Austria — [2]School of Physics and Astronomy, University of Nottingham, Nottinhgham, UK

We study two ions confined in a Penning trap. We show that electronically highly excited states exist in which an electron is delocalized among the two ions forming a giant molecule of several micrometer size. At energies close to the top of the Coulomb barrier these molecular states can be regarded as superpositions of Rydberg states of individual ions. We illuminate the possibility to observe coherent charge transfer between the ions. Beyond a critical principal quantum number the electron can coherently tunnel through the Coulomb barrier to an adjacent doubly charged ion. The tunneling occurs on timescales on which the dynamics of the nuclei can be considered frozen and radiative decay can be neglected. The present study can be regarded as a first step towards the implementation of electronic Hubbard models in an ion trap setup.

[1] I. Lesanovsky, M. Müller and P. Zoller, arXiv:0809.3213 (2008)

A 27.4 Do 15:15 VMP 6 HS-C
Collective effects in ultracold atomic clouds interacting with a high-finesse resonator — •Simone Bux, Gordon Krenz, Sebastian Slama, Philippe Courteille, and Claus Zimmermann — Physikalisches Institut, Universität Tübingen

We study the coupled dynamics of ultracold or Bose-condensed atomic clouds or interacting with the modes of an optical high-finesse ring resonator. Our interest is focused on collective effects taking place in such systems, like Collective Atomic Recoil Lasing or superradiant Rayleigh scattering. We load ultracold atomic clouds into the light field supported by a laser-pumped ring resonator. Density fluctuations in the atomic cloud lead to strong transient backscattering of light, which is recorded in real time. The scattering couples and populates several quantized momentum states resolved in time-of-flight absorption images. Both, the optical and the matter wave signals are studied as a function of collective gain and detuning of the pump laser from the cavity resonance. We particularly focus our attention to the emergence of signatures of quantized motion in the gain profile and the threshold behaviour of the collective instability.

A 27.5 Do 15:30 VMP 6 HS-C
Scattering of ultra-cold atoms by nano-cylinders — •Andrés Naranjo, Javier Madroñero, and Harald Friedrich — Physik Department, TU München, Germany

Different scattering properties, like quantum reflection, are studied for the interaction between an ultra cold atom and a grounded perfectly conducting cylinder. For this, an expression for the interaction potential of a cylinder-dipole configuration is derived for the non retarded regime. This is an acceptable model which assumes that the atom interacts via its dipole polarizability. The calculation uses the traditional Green's function method in cylindrical coordinates imposing Dirichlet boundary conditions [1]. For large separations the potential exhibits explicitly the contribution of each of the dipole components to the interaction. It is shown that the radial and axial components share the same dependence on the separation r and cylinder radius R, namely $1/\left(r^3 \log(r/R)\right)$, while the component perpendicular to these two has the form $1/r^5$ with a proportionality constant depending on the cross section area of the cylinder. The validity of this asymptotic behavior is numerically verified against the exact potential for realistic situations, e.g. helium atoms interacting with nanowires [2].

[1] J.A. Hernandes and A.K.T. Assis, *J. Electrostatics* **63**, 1115 (2005).
[2] A. Naranjo *et al.*, in preparation.

A 27.6 Do 15:45 VMP 6 HS-C
Oscillation and stability of Dark-Bright solitons in cigar-shaped BECs — •Stephan Middelkamp[1], Panayotis Kevrekidis[2], and Peter Schmelcher[1,3] — [1]Theoretische Chemie, Physikalisch-Chemisches Institut, Universität Heidelberg, INF 229, 69120 Heidelberg, Germany — [2]Department of Mathematics and Statistics, University of Massachusetts, Amherst MA 01003-4515, USA — [3]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg, Germany

We derive effective 1D vector equations that govern the axial dynamics of mean-field cigar-shaped condensates consisting of atoms in two different internal states with repulsive interactions. These coupled equations take into account the contributions of the transverse degree of freedom accuratley. We apply the equations to predict the oscillation frequency of dark-bright solitons in cigar-shaped traps and investigate their stability using a Bogoliubov-de-Gennes analysis.