Q 28: Ultra Cold Atoms, Ions and BEC II (with A)

Time: Wednesday 10:30–12:30 Location: F 303

Q 28.1 We 10:30 F 303

Creating versatile atom traps by combining laser light and magnetic fields — •Stephan Middelkamp[1], Michael Mayle[1], Igor Lesanovsky[2], and Peter Schmelcher[1] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Hamburg, Germany — [2]School of Physics and Astronomy, Faculty of Science, University of Nottingham, Nottingham, UK

We utilize the combination of two standard trapping techniques, a magnetic trap and an optical trap in a Raman setup, to propose a new versatile and tunable trap for cold atoms. The thus created potential has got several advantages compared to conventional trapping potentials: One can easily convert the type of the trap, e.g. from a single well to a double well trap. One can trap atoms in different internal states in different trap types enabling the realization of new experiments with multi-component Bose-Einstein condensates. One can achieve variations of the trapping potential on small length scales ($\sim \mu$m) without the need for microstructures. We present the potential surfaces for different setups, show their tunability, give a semi-analytical expression for the potential, and propose experiments which can be realized within such a trap.

Q 28.2 We 10:45 F 303

Few-boson tunneling in a double well with spatially modulated interaction. — •Budhaditya Chatterjee[1], Ioannis Brouzos[2], Sascha Zöllner[3], and Peter Schmelcher[2] — [1]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg, Germany — [2]Zentrum für Optische Quantentechnologien , Universität Hamburg, Luruper Chaussee 149, Gebäude 69, 22761 Hamburg, Germany — [3]Niels Bohr International Academy, Niels Bohr Institute, Blegdamsvej 17, 2100 Copenhagen, Denmark

We study few-boson tunneling in a one-dimensional double well with a spatially modulated interaction. The dynamics changes from Rabi oscillations in the non-interacting case to a highly suppressed tunneling for intermediate coupling strengths followed by a revival near the fermionization limit. The dynamics is explained on the basis of the few-body spectrum and stationary eigenstates. For higher number of particles, $N \geq 3$ it is shown that the inhomogeneity of interaction can be tuned to generate tunneling resonances. Finally a tilted double-well and its interplay with the interaction asymmetry is discussed.

Q 28.3 We 11:00 F 303

Superconducting Atom Chips — Tobias Mueller[1,2], Rachele Fermani[1,2], Bo Zhang[1], Kin Sung Chan[1], Michael J. Lim[1,3], and •Rainer Dumke[1] — [1]School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore — [2]Centre for Quantum Technologies, National University of Singapor, Singapore — [3]Rowan University, New Jersy, USA

We store and control ultra-cold atoms in a new type of trap using magnetic fields of vortices in a high temperature superconducting microstructure. This is the first time ultra-cold atoms have been trapped in the field of magnetic flux quanta. We generate the attractive trapping potential for the atoms by combining the magnetic field of a superconductor in the remanent state with external homogeneous magnetic fields. We show the control of crucial atom trap characteristics such as an efficient intrinsic loading mechanism, spatial positioning of the trapped atoms and the vortex density in the superconductor. The measured trap characteristics are in good agreement with our numerical simulations.

Q 28.4 We 11:15 F 303

Rotating three-dimensional solitons in Bose Einstein condensates with attractive nonlocal interaction — Fabian Maucher[1], Stefan Skupin[1,2], and •Wieslaw Krolikowski[3] — [1]Max Planck Institute for the Physics of Complex Systems — [2]Friedrich-Schiller-University, Institute of Condensed Matter Theory and Solid State Optics, 07743 Jena, Germany — [3]Laser Physics Centre, Research School of Physics and Engineering, Australian National University, Canberra, ACT 0200, Australia

We study the dynamics of rotating high order solitons (azimuthons) in Bose Einstein condensates with attractive nonlinear, nonlocal and isotropic interaction. In particular, we consider a “Gaussian” and a “1/r”-response, i.e., prototypes for short and long-range interaction. Azimuthons are a straightforward generalization of usual (nonrotating) solitons and feature an additional parameter, the angular frequency. The most simple three-dimensional azimuthons are tori with angular phase ramp and azimuthal amplitude modulations. Approximate variational methods allow a rather good approximation of the angular velocity of the azimuthons (compared to full 3d numerical simulation). It is possible to control this angular frequency by varying the repulsive contact interaction using Feshbach resonance techniques. The observed structures are very robust, even in cases where the initial conditions are rather far from the exact solutions. We conjecture that self-trapped azimuthons are generic for condensates with attractive nonlocal interaction.

Q 28.5 We 11:30 F 303

Two-way conversations between cold atoms and semiconductors — •Thomas Judd[1,2], Robin Scott[2], German Sinuco[2], Tom Montgomery[2], Andrew Martin[3], Peter Krüger[2], and Mark Fromhold[2] — [1]University of Tübingen, Germany — [2]University of Nottingham, UK — [3]University of Melbourne, Australia

There has been significant work in the past few years on hybrid devices which combine cold atoms with solid state structures. The hope is to create devices which combine the key advantages of both systems - the purity of a quantum coherent atom cloud, and the versatility of microchips - to study fundamental physics and further quantum technologies. To date there has been much success in manipulating cold atoms with microchips and semiconductors to create a measurable signal in the atom cloud. However, it has not been possible to perform the reverse procedure of using cold atoms to create a measurable signal in a solid state device. If this two-way coupling can be achieved, a range of possibilities open up such as long-term quantum memory chips. Here we use simulations to show that Fresnel zone plates could assist these efforts by strongly and coherently focusing ultracold atoms onto a semiconductor chip with a two-dimensional electron gas (2DEG). The atoms are shown to deplete the 2DEG, thereby strongly increasing its resistivity to measurable levels. The technique provides a solution to the long standing problem of short-range atom focusing while at the same time opening the door to a new form of non-destructive lithography which can create electronic components on a 50nm scale.

Q 28.6 We 11:45 F 303

An AC electric trap suitable for ground-state CO molecules — •Amudha Kumari Duraisamy, Adela Marian, Wieland Schöllkopf, and Gerard Meijer — Fritz-Haber-Institut, Faradayweg 4-6, Berlin, Germany

When trapping polarizable neutral particles using AC electric fields, the parameter which determines the strength of the interaction is α/m, where α is the (total) quadratic Stark coefficient and m is the mass of the particle. As this ratio is nearly identical for ^{87}Rb and ^{12}CO in their ground states, they would behave very similarly when confined in an AC electric trap. We have already demonstrated and studied trapping of ground-state Rb in a macroscopic AC electric trap with a depth of a few microkelvins [1, 2] . We now propose to use the Rb atoms as a case study for the behaviour of AC-trapped ground-state CO molecules.

To this end, we have implemented a new AC trap where all the dimensions were scaled down by a factor of two to increase the available trap depth. Stable electric trapping is observed in a wider range of switching frequencies around 300 Hz, in agreement with trajectory calculations. We have trapped about 1.3×10^5 atoms with densities of 8×10^9 cm^{-3} for an electric field of 60 kV/cm at the center of the trap.

Refrences

1. S. Schlunk et al., PRL **98**, 223002(2007),
2. S. Schlunk et al., PRA **77**, 043408(2008)

Q 28.7 We 12:00 F 303

Gap and screening in Raman scattering of a Bose condensed gas — •Patrick Navez[1] and Kai Bongs[2] — [1]Universitaet Duisburg-Essen, Lotharstrasse 1, 47057 Duisburg, Germany — [2]University of Birmingham, Edgbaston, Birmingham, B15 2TT, England

We propose different spectroscopic methods to explore the nature of the thermal excitations of a trapped Bose condensed gas: 1) a four photon process to probe the uniform region in the trap center: 2) a stimulated Raman process in order to analyze the influence of a momentum transfer in the resulting scattered atom momentum distribution. We apply these methods to address specifically the energy spectrum and the scattering amplitude of these excitations in a transition between two hyperfine levels of the gas atoms. In particular, we exemplify the potential offered by these proposed techniques by contrasting the spectrum, expected from the non conserving Bogoliubov approximation valid for weak depletion, to the spectrum of the finite temperature extensions like the conserving generalized random phase approximation (GRPA). Both predict the existence of the Bogoliubov collective excitations but the GRPA approximation distinguishes them from the single atom excitations with a gapped and parabolic dispersion relation and accounts for the dynamical screening of any external perturbation applied to the gas. Two feasible experiments are discussed, one concerns the observation of the gap associated to this second branch of excitations and the other deals with this screening effect. Ref: P. Navez and K. Bongs, Eur. Phys. Lett. (in press).

Q 28.8 We 12:15 F 303

Cold atoms near superconductors — •Helge Hattermann, Florian Jessen, Brian Kasch, Daniel Cano, Max Kahmann, Dieter Koelle, Reinhold Kleiner, and József Fortágh — Physikalisches Institut, Eberhard-Karls-Universität Tübingen, CQ Center for Collective Quantum Phenomena and their Applications, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

We report on the measurement of atomic spin coherence near the surface of a superconducting niobium wire. As compared to normal conducting metal surfaces, the atomic spin coherence is maintained for time periods beyond the Johnson noise limit. The result provides experimental evidence that magnetic near field noise is strongly suppressed close to the superconductor. For very small distances to the wire surface, the magnetic field exclusion due to the Meissner effect reduces the trap depth and leads to atom losses. Based on our results, we discuss possibilities to circumvent these detrimental losses and to coherently couple ultracold atoms to solid state devices, opening the way towards the construction of hybrid quantum systems.