Q 46: Quantengase (Wechselwirkungseffekte)

Zeit: Mittwoch 16:30–18:45 Raum: 6J

Q 46.1 Mi 16:30 6J

Properties of Canonical Ensembles for Weakly Interacting Dipolar Gases — •Konstantin Glaum[1], Hagen Kleinert[1], Axel Pelster[2], and Lance Labun[3] — [1]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany — [3]Dartmouth College, 03755 Hanover, NH, USA

We set up a recursion relation for the partition function of a finite number of harmonically confined dipolar bosons, and derive analytic expressions for free energy, specific heat, and ground-state occupancy. Due to the diluteness of the gas, both the isotropic contact interaction and the anisotropic dipole-dipole interaction are treated perturbatively. A subsequent renormalization of physical parameters yields a self-consistent improvement of the perturbative results. Due to the anisotropy of the dipole-dipole interaction, the thermodynamic quantities of interest depend on the trap configuration. In a cylindrical symmetric trap, there are two extremal configurations, where the symmetry axes of the trap and the dipole-dipole interaction are parallel or perpendicular to each other. By considering the difference between those two configurations we derive observable results which are sensitive to the small anisotropic dipole-dipole interaction.

Q 46.2 Mi 16:45 6J

Large ensembles of ultracold atoms in an ultrahigh-finesse optical cavity — •Stephan Ritter, Tobias Donner, Ferdinand Brennecke, Anton Öttl, Thomas Bourdel, Michael Köhl, and Tilman Esslinger — Institut für Quantenelektronik, ETH Zürich, 8093 Zürich, Schweiz

The presence of very large numbers of atoms inside an ultrahigh-finesse optical cavity leads to an extremely strong coupling between light and matter. Therefore unprecedentedly large vacuum Rabi splittings can be observed in such systems. The properties of the coupled atom-cavity system drastically differ from those of its bare constituents and allow to study the collective behavior of the atom sample.

In our setup, we produce a Bose-Einstein condensate of ^{87}Rb atoms in a magnetic trap 36 mm above an ultrahigh-finesse optical cavity [1]. We vertically transport more than 10^5 atoms from the magnetic trap into the cavity mode using a red-detuned standing wave. Inside the cavity, various beam geometries allow for the trapping and manipulation of the atom cloud. We study the transmission properties of the cavity in the presence of large atom numbers. Alternatively, the atoms are pumped from the side and the light scattered into the cavity mode is analyzed. Properties and capabilities of the coupled system of an ultrahigh-finesse optical cavity and a large ensembles of atoms are described and the current status of the experiment is reviewed.

[1] A. Öttl, S. Ritter, M. Köhl, and T. Esslinger,Rev. Sci. Instrum. **77**, 063118 (2006).

Q 46.3 Mi 17:00 6J

Scattering of two-dimensional solitons in dipolar Bose-Einstein condensates — •Rejish Nath[1], Paolo Pedri[2], and Luis Santos[1] — [1]Institut fuer theoretische Physik, Leibniz-Universitaet Hannover, Appelstr. 2, D-30167 Hannover — [2]Laboratoire de Physique Theorique et Modeles Statistique, Universite Paris Sud, 91405 Orsay Cedex, Frankreich

We analyze the scattering of bright solitons in dipolar Bose-Einstein condensates placed in unconnected layers. Whereas for short-range interactions unconnected layers are independent, a remarkable consequence of the dipole interaction is the appearance of novel nonlocal interlayer effects. In particular, we show that the interlayer interaction leads to an effective molecular potential between disconnected solitons, inducing a complex scattering physics between them, which includes inelastic fusion into soliton-molecules, and strong symmetric and asymmetric inelastic resonances. In addition, a fundamentally new 2D scattering scenario in matter-wave solitons is possible, in which inelastic spiraling occurs, resembling phenomena in photorrefractive materials. Finally, we consider the scattering of unconnected 1D solitons and discuss the feasibility in current on going experiments.

Q 46.4 Mi 17:15 6J

Strongly correlated dipolar gases in optical lattices — •Giovanni Mazzarella, Arturo Argüelles, and Luis Santos — Insitiut für Theoretische Physik, Leibniz Universität Hannover

We analyze the physics of strongly correlated dipolar gases in optical lattices. We first discuss the case of spatially unconnected neighboring 1D systems, which are however interacting non-locally due to the dipolar interactions. We show, that the nonlocal interactions lead to a Mott-insulator-to-pair-superfluid transition that induces a significant modification of the Mott-insulator phases for low filling factors. We discuss the effects that this distortion may have on the spatial extension of the Mott-insulator plateaux in experiments with an harmonic confinement overimposed to the lattice potential, showing that anti-intuitively the Mott-insulator plateaux may become broader for increasing tunneling. We extend our analysis to nonlocally coupled 2D lattices by means of the corresponding mean-field calculations. In a second part, we study the conditions to achieve a significant collisionally-induced tunneling assisted by the dipole-dipole interaction. The effect of this new term in the Bose-Hubbard Hamiltonian, which resembles (but is not equivalent to) the so-called correlated-hopping in frustrated quantum magnets, are analyzed by means of a mean-field approach.

Q 46.5 Mi 17:30 6J

Investigation of a chromium BEC in the vicinity of a Feshbach resonance — •Thierry Lahaye, Tobias Koch, Marco Fattori, Bernd Fröhlich, Axel Griesmaier, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany

Due to its large magnetic moment (6 Bohr magnetons), tuning the scattering length of chromium atoms by using a magnetic Feshbach resonance is a promising way to the realization of a purely dipolar quantum gas. We have modified our BEC apparatus, with which we have already measured dipolar effects on the expansion dynamics of a BEC [Phys. Rev. A **74**, 013621 (2006)], to investigate the BEC near a resonance at 590 G. This resonance has an expected width of 1.7 G. Using fast switching magnetic fields and a high field imaging system we are now able to condense above this resonance and investigate the BEC in its vicinity. We report on the recent experimental progress.

Q 46.6 Mi 17:45 6J

Detecting correlated quantum phases in ultracold atoms — •Michael Köhl[1], Corinna Kollath[2], and Thierry Giamarchi[2] — [1]Cavendish Laboratory, University of Cambridge, Madingley Road, Cambridge CB3 0HE, United Kingdom — [2]DPMC-MaNEP, University of Geneva, 24 Quai Ernest-Ansermet, 1211 Geneva, Switzerland

Cold atomic systems provide a unique setup to explore the properties of strongly correlated quantum particles. However, despite the high degree of tunability and control offered by these systems, they are difficult to probe, making the identification of the exotic quantum phases extremely involved. Here we propose a novel experimental probe, using the coherent coupling of a single particle to the system.

Q 46.7 Mi 18:00 6J

BEC with $1/r$ Interatomic Interaction — •Moritz Schütte[1] and Axel Pelster[2] — [1]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany

We consider the thermodynamic properties of a Bose-Einstein condensate with laser induced attractive $1/r$ interatomic interaction. Such a system is self-stabilizing and serves as a test laboratory for simulating gravitating objects with huge masses [1]. Using the functional integral approach, we derive a Hartree-Fock mean-field theory and investigate as two special cases the region around absolute zero and around the critical temperature. At first, we obtain an analytic solution of the Gross-Pitaevskii equation in Thomas-Fermi approximation and use a time-dependent variational approach in order to investigate the collective excitations. Then we determine the leading shift of the critical temperature which is due to the $1/r$ interaction and discuss its dependence upon the geometry of an additional harmonic confining potential.

[1] D. O'Dell, S. Giovanazzi, G. Kurizki, and V. M. Akulin Phys. Rev. Lett. 84, 5687 (2000)

Q 46.8 Mi 18:15 6J

Bose-Einstein condensates with attractive $1/r$ interaction: The case of self-trapping — •Ioannis Papadopoulos and Günter Wunner — Institut für theoretische Physik 1, Universität Stuttgart, D-70550 Stuttgart

Amplifying on a proposal by O'Dell *et al.* for the experimental realization of Bose-Einstein condensates of neutral atoms with attractive $1/r$ interaction, we point out that the instances of self-trapping of the condensate, without external trap potential, are physically best understood by introducing appropriate "atomic" units. This reveals a remarkable scaling property: The physics of self-trapping depends only on the parameter N^2a/a_u, where N is the particle number, a the scattering length, and a_u the appropriate "Bohr" radius. We calculate accurate numerical results for self-trapping wave functions and potentials, for energies, sizes and peak densities, and compare with previous variational results.

Q 46.9 Mi 18:30 6J

Excited states of Bose-Einstein condensates with attractive $1/r$ interaction — •Patrick Wagner and Günter Wunner — Institut für Theoretische Physik 1, Universität Stuttgart, D-70550 Stuttgart

We study excited states of Bose-Einstein condensates which consist of bosons interacting via the ususal contact potential plus an additional electromagnetically induced gravity-like $1/r$-potential. The dependence of energies, wave functions and potentials on the distribution of the particles on different orbitals, as well as the choice of the different orbitals, determined in a self-consistent way, will be discussed.