Q 8 Quantengase II

Zeit: Montag 14:00–16:00 Raum: HVI

Q 8.1 Mo 14:00 HVI

Superfluid-Insulator Transition in a Periodically Driven Optical Lattice — •Andre Eckardt, Christoph Weiss, and Martin Holthaus — Institut fuer Physik, Carl-von-Ossietzky-Universitaet, 26111 Oldenburg

We demonstrate that the transition from a superfluid to a Mott insulator in the Bose–Hubbard model can be induced by an oscillating force through an effective renormalization of the tunneling matrix element. The mechanism involves adiabatic following of Floquet states, and can be tested experimentally with Bose–Einstein condensates in periodically driven optical lattices.

Q 8.2 Mo 14:15 HVI

How correlation functions illuminate the frontiers of an extended mean-field theory in a quasi-1D Bose gas — •M. Eckart, R. Walser, and W. P. Schleich — Abteilung Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

Quasi-1D systems have gained a lot of interest, because they have recently been experimentally realized in the context of ultracold gases and have always been a valuable playground for theorists due to the fact, that exact solutions exist for a reduced dimensionality. One of the most interesting questions is how to describe the cross-over from the Gross-Pitaevskii regime of weakly correlated bosons ($\gamma \ll 1$) to the Tonks-Girardeau regime of strongly correlated bosons ($\gamma \gg 1$). The most sensitive experimentally available observable that can be used to study this cross-over is the third-order correlation function which is proportional to the directly measurable three-body recombination rate.

Although the quasi-1D case is the harshest environment for a mean-field theory, we show how an extension, which also includes density fluctuations and pairing fields, can be used to describe the cross-over up to values of $\gamma \approx 1$. As any mean-field theory is known to fail in the strongly correlated regime, we give a detailed analysis of how far an extended mean-field theory can be pushed. The benefit of our approach lies in the fact that correlation functions emerge naturally and that we obtain results for the homogeneous as well as the experimentally relevant trapped case. In the region where an extended mean-field theory is applicable we also present the first calculations of the full behavior (diagonal and off-diagonal) of correlation functions up to third order.

Q 8.3 Mo 14:30 HVI

Resonanzphänomene in $F = 1$ und $F = 2$ ^{87}Rb Spinor-Kondensaten — •Jochen Kronjäger, Christoph Becker, Martin Brinkmann, Lars Neumann, Sebastian Schnelle, Kai Bongs und Klaus Sengstock — Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

Neue experimentelle und theoretische Untersuchungen von $F = 1$ Spinorkondensaten haben das grundlegende Verständnis der kohärenten Spindynamik in diesem System weit vorangebracht. Uns ist es z.B. gelungen, einen speziellen Anfangszustand definierter Phase zu präparieren und dessen gemessene Entwicklung analytisch zu beschreiben [1]. Arbeiten in der Gruppe von M. Chapman demonstrierten die kohärente Kontrolle der Spindynamik mit Magnetfeldpulsen [2].

Ein spannender Aspekt der Dynamik in $F = 1$ im zweidimensionalen Phasenraum in Analogie zum starren Pendel [3] ist die Vorhersage einer Divergenz der Oszillationsperiode für bestimmte Anfangswerte, wie beim Übergang vom schwingenden zum rotierenden Pendel.

Eine derartige Resonanz konnte nun in $F = 2$ ^{87}Rb erstmals vermessen werden. Wir diskutieren eine neuartige Interpretation des Phänomens als nichtlineare Phasenanpassung analog zum optischen Vier-Wellen-Mischen. Diese weiterführende Interpretation erlaubt ein qualitatives Verständnis unabhängig von der detaillierten Phasenraumdynamik, die im Fall $F = 2$ hoch komplex ist.

[1] J. Kronjäger et al., cond-mat/0509083 (2005)
[2] M.-S. Chang et al., Nature Physics **1**, 111-116 (2005)
[3] W. Zhang et al., Phys. Rev. A **72**, 013602 (2005)

Q 8.4 Mo 14:45 HVI

Stability of a Dilute Ultracold Trapped Gas of Bose and Fermi Atoms — •Steffen Röthel[1] and Axel Pelster[2] — [1]Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Universitätsstraße 5, 45117 Essen, Germany

Considering the grand-canonical partition function of a Bose-Fermi mixture, we integrate out the fermionic field and derive the effective action of the Bose subsystem. Its extremization at zero temperature yields in the Thomas-Fermi limit an algebraic Gross-Pitaevskii equation for the condensate wave function. Within this approximation we determine the density profiles of both components in a ^{87}Rb–^{40}K mixture where the δ-interaction is repulsive between the bosons and attractive between both components.

Furthermore, we investigate the stability of the Bose-Fermi mixture with respect to collapse by evaluating numerically the effective action for a trial Gaussian density profile of the condensate. We find that the instability occurs in the center of the density profile, and that the critical numbers of bosons and fermions are reciprocal to each other. Our results, which strongly depend on the numerical value of the Bose-Fermi s-wave scattering length, are compared with recent experiments on ^{87}Rb–^{40}K mixtures in Florence and Hamburg.

Q 8.5 Mo 15:00 HVI

Rotating Bose-Einstein Condensates in Anharmonic Traps — •Sebastian Kling[1] and Axel Pelster[2] — [1]Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Universitätsstraße 5, 45117 Essen, Germany

We study a Bose gas within a rotating anharmonic trap in the corotating frame. In the fast rotating regime, interesting physics takes place, since the centrifugal force overcompensates the harmonic confinement, so the trapping potential becomes Mexican-hat shaped. We calculate the eigenfrequencies of the vortex-free condensate at zero temperature for low energy excitations and the velocity profile after switching off the trap. Furthermore, we discuss how thermodynamic properties such as the critical temperature and the heat capacity of the Bose gas depend on the rotation frequency.

Q 8.6 Mo 15:15 HVI

Critical Temperatures of $F = 1$ Spinor Condensate — •Parvis Soltan-Panahi[1], Axel Pelster[2], and Hagen Kleinert[1] — [1]Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Universitätsstraße 5, 45117 Essen, Germany

Applying the functional integral approach of many-body theory, we investigate the thermodynamical properties of a spinor condensate with spin $F = 1$. At first, we neglect any two-particle interaction and compute the temperature dependence of the specific heat and the magnetic susceptibility. Furthermore, we determine how the critical temperatures for the occurrence of the ferromagnetic and the antiferromagnetic phase change with the magnetization of the system. Finally, we elaborate how these critical temperatures are affected by additional short-range two-particle interactions within a mean-field approximation.

Q 8.7 Mo 15:30 HVI

Interference of an array of atom lasers — •Carsten Geckeler, Giovanni Cennini, Gunnar Ritt, and Martin Weitz — Physikalisches Institut, Auf der Morgenstelle 14, 72076 Tübingen

We report on the observation of interference of a series of atom lasers. A comb-like array of coherent atomic beams is generated by outcoupling atoms from distinct Bose-Einstein condensates confined in the independent sites of a mesoscopic optical lattice. The observed interference signal arises from the spatial beating of the overlapped atom laser beams, which is monitored over a range corresponding to 2 ms of free fall time. The average relative de Broglie frequency of the atom lasers was measured.

Q 8.8 Mo 15:45 HVI

An analytical study of resonant transport of Bose-Einstein condensates — •Kevin Rapedius, Dirk Witthaut, and Hans Jürgen Korsch — Technische Universität Kaiserslautern, FB Physik, D-67653 Kaiserslautern, Germany

We study the stationary nonlinear Schrödinger equation, or Gross-Pitaevskii equation, for a one-dimensional finite square-well potential. By neglecting the mean-field interaction outside the potential well it is possible to discuss the transport properties of the system analytically in terms of ingoing and outgoing waves. Resonances and bound states are obtained analytically. The transmitted flux shows a bistable behaviour. Novel crossing scenarios of eigenstates similar to beak-to-beak structures are observed for a repulsive mean-field interaction. One can prove that resonances transform to bound states due to an attractive nonlinearity and vice versa for a repulsive nonlinearity, and the critical nonlinearity for the transformation can be calculated analytically. The bound state wavefunctions of the system satisfy an oscillation theorem as in the case of linear quantum mechanics. Furthermore, the implications of the eigenstates on the dymamics of the system are discussed.