Q 5: Quantengase II [gemeinsam mit A]

Zeit: Montag 16:30–19:00 Raum: 1A

Hauptvortrag Q 5.1 Mo 16:30 1A

Dynamical quantum phase transitions — •Ralf Schuetzhold — TU Dresden, Institut fuer Theoretische Physik

A sweep through a quantum phase transition by means of a time-dependent external parameter entails non-equlilibrium phenomena (break-down of adiabaticity): Since the energy gap vanishes at the critical point, the response time diverges and thus the external time-dependence drives the system away from the ground state (assuming zero temperature initially). In this way, the initial quantum fluctuations are amplified and may become observable. By means of several examples based on ultra-cold atoms, possible effects of these amplified quantum fluctuations are studied and universal features (such as freezing) are discussed.

Gruppenbericht Q 5.2 Mo 17:00 1A

Bose-Einstein condensates in presence of defects and disorder. — •Tobias Paul, Mathias Albert, Nicolas Pavloff, and Patricio Leboeuf — Laboratoire de Physique Théorique et Modèles Statistiques, Universite Paris Sud, F-91405 Orsay

Superfluidity and Anderson localization are genuine many-body manifestations of quantum coherence which are nowadays revisited in dilute Bose gases. Recent theoretical results obtained in our group in Orsay are reviewed: First, we study the coherent flow of interacting Bose-condensed atoms in presence of a single defect or an extended disorder potential. We discuss the different regimes of quantum transport induced by a variation of the condensate flow-velocity v: We point out that for v much smaller than the sound velocity c the flow is in general superfluid, whereas beyond a critical velocity the formation of solitons and shockwaves sets on. For $v \gg c$, a regime of quasi-dissipationless transport is found. There, for long disorder samples, the system enters an Anderson localized phase.

In a second step, we consider the experimental relevant case where a harmonic trap is superimposed to the defect potential. We obtain a global picture characterizing the dynamical properties of the dipole oscillations where we recover the different regimes of quantum transport introduced in the first part of the talk. We discuss our findings in the context of recent experiments [1,2] and address the question under which circumstances Anderson localization could be observed.

[1] J. E. Lye et al., Phys. Rev. A 75, 061603 (2007)

[2] P. Engels and C. Atherton, Phys. Rev. Lett. 99, 160405 (2007)

Gruppenbericht Q 5.3 Mo 17:30 1A

Tailoring quasi-particles in ultra-cold matter: soliton oscillations, longest lifetimes and fillings. — •Christoph Becker[1], Parvis Soltan-Panahi[1], Simon Stellmer[1], Sören Dörscher[1], Eva-Maria Richter[1], Mathis Baumert[1], Jochen Kronjäger[1], Kai Bongs[1,2], and Klaus Sengstock[1] — [1]Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg — [2]Midlands Centre for Ultracold Atoms, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK

Solitons are distinguishing features of many non-linear physical systems. Stabilized by a balance between spreading due to dispersion and focusing mediated by non-linearities, solitons emerge as non-spreading wavepackets. BEC's provide fascinating possibilities concerning quantum-state engineering, necessary for the creation and observation of solitons. Dark solitons appear as dips in the density distribution and have so far been produced in few experiments limited by very short lifetimes.
Here we report on the generation of dark solitons in an optically trapped ^{87}Rb BEC with an extraordinary life-time of up to several seconds. For the first time, we observe oscillations of dark solitons with a characteristic frequency in excellent agreement with theoretical predictions. By filling the dark soliton with atoms in another hyperfine state we are able to create dark-bright solitons with a substantially greater oscillation period.
The experimental results are combined with theoretical studies based on the Gross-Pitaevskii equation.

Gruppenbericht Q 5.4 Mo 18:00 1A

Strongly interacting Fermi gases in an optical lattice — •Henning Moritz[1], Niels Strohmaier[1], Robert Jördens[1], Kenneth J. Günter[1,2], Yosuke Takasu[1,3], Michael Köhl[1,4], and Tilman Esslinger[1] — [1]Institute of Quantum Electronics, ETH Zürich, Hönggerberg, CH-8093 Zürich, Switzerland — [2]Department for Electronic Science and Engineering, Kyoto University, Japan — [3]Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, United Kingdom — [4]Laboratoire Kastler Brossel, 24, rue Lhomond, 75005 Paris

When fermionic atoms are placed in the periodic potential of an optical lattice, they behave very much like electrons in a solid. However, the properties of this synthetic material can be changed at will. Here, we report on the experimental realization and investigation of strongly interacting Fermi gases with tunable interactions.

By changing the attractive interaction strength we are able to control the transport properties: while dipole oscillations are observed for a non-interacting gas, the cloud relaxes very slowly to its equilibrium position for strong attractive interactions. We suggest an interpretation in the framework of the Hubbard model including external confinement. The strong attraction induces bound states, which can only tunnel very slowly via second order processes.

Furthermore, experiments on the behavior of repulsive Fermi gases will be presented.

Gruppenbericht Q 5.5 Mo 18:30 1A

First Bose-Einstein Condensate in microgravity — •Tim van Zoest[1], Wojtek Lewoczko-Adamczyk[2], and Anika Vogel[3] for the QUANTUS-Collaboration — [1]Institut für Quantenoptik, Leibniz-Universität Hannover — [2]Institut für Physik, Humboldt Universität Berlin — [3]Institut für Laserphysik, Universität Hamburg

Promising techniques for fundamental tests in the quantum domain are matter-wave sensors based on cold atoms, which use atoms as unperturbed microscopic test bodies for measuring inertial forces or as frequency references. Microgravity is of high relevance for matter-wave interferometers and experiments with quantum matter, like Bose-Einstein-condensates , as it permits the extension of an unperturbed free fall in a low-noise environment.

The project QUANTUS is a feasibility study of a compact, robust and mobile experiment for the creation of a BEC in a weightlessness environment at the droptower in Bremen (ZARM). The experiment has to be implemented in a dropcapsule with a length of 215 cm and 60 cm diameter and has to withstand forces up to 50 g (1). The experimental setup as well as the latest results, the realization of the first weightlessness Bose-Einstein Condensate with longest time of flights and the adiabatic expansion to very shallow traps (less than 20 Hz), are described. In future, the apparatus will serve as an experimental platform to investigate various aspects of ultra-cold gases in microgravity like adiabatic release, extended coherent evolution and features of atom lasers.

(1) A. Vogel et al., Appl. Phys. B, 84, 04 (2006)