

Q 40: Quantengase (Spinor-Gase)

Zeit: Mittwoch 14:00–15:45

Raum: 6J

Q 40.1 Mi 14:00 6J

Vortex quantum creation and winding number scaling in a quenched spinor Bose gas — MICHAEL UHLMANN¹, RALF SCHÜTZHOLD¹, and UWE R. FISCHER² — ¹Institut für Theoretische Physik, Technische Universität Dresden, D-01062 Dresden, Germany — ²Eberhard-Karls-Universität Tübingen, Institut für Theoretische Physik, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

Motivated by a recent experiment, we study non-equilibrium quantum phenomena taking place in the quench of a spinor Bose gas through the zero-temperature phase transition separating the polar paramagnetic phase and the ferromagnetic phase. We derive the typical domain structure created by the quench arising due to spin-mode fluctuations, and establish a sample-size scaling law for the creation of spin vortices, which are topological defects in the transverse magnetization.

Q 40.2 Mi 14:15 6J

Teaching the old dog new tricks: Quantum dynamics of atomic coherence in spin-1 condensates — LEV PLIMAK¹, REINHOLD WALSER¹, WOLFGANG SCHLEICH¹, KAI BONGS², and KLAUS SENGSTOCK² — ¹Universität Ulm, Institut für Quantenphysik, D-89069 Ulm — ²Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

Recent spectacular developments in optical cooling and trapping of atoms were preceded by the thorough investigation of interactions of the polarised laser beam with atoms in the sixties, seventies and eighties, in which the concept of atomic coherence played a prominent role. We review this concept in the context of spinor condensates and show that it provides one with a physically natural viewpoint with a link to a multitude of established techniques. In addition, access to two-body correlations in the spinor condensates through time-resolved measurement of atomic coherence is discussed.

Q 40.3 Mi 14:30 6J

Exploring the correspondence principle with spinor condensates — CARSTEN WEISS, REINHOLD WALSER, WOLFGANG P. SCHLEICH, and LEV PLIMAK — Institut für Quantenphysik, Universität Ulm, Ulm, Deutschland

Studying many-body quantum physics requires a priori insight into the nature of the quantum state. In the context of three-dimensional condensed bosonic gases, the Gross-Pitaevskii mean-field approximation proved to be very successful in the last decade. However current experiments progress towards lower dimensional and strongly correlated systems [1].

In this contribution we will discuss a basic approach to study the nature of the quantum state in Fock space. By studying a spinor condensate [2-4] in a few mode Born-Oppenheimer approximation we can describe the semi-classical as well as full quantum mechanical dynamics of the system. We find distinctively different behavior for the collective response, which can be either continuous Bogoliubov excitations or discrete Bloch oscillations in Fock space.

[1] B. Paredes *et al.*, *Nature* **429**, 277 (2004)[2] W. Zhang *et al.*, *Phys. Rev. A*, **72**, 013602 (2005).[3] J. Kronjäger *et al.*, *Phys. Rev. A*, **72**, 1 (2005).[4] L. Plimak *et al.*, *Opt. Comm.* **264**, 311 (2006).

Q 40.4 Mi 14:45 6J

Reversible quantum phase dispersion in ultracold spinor gases — ARTUR WIDERA¹, SIMON FÖLLING¹, STEFAN TROTZKY¹, PATRIK CHEINET¹, FABRICE GERBIER², and IMMANUEL BLOCH¹ — ¹Institut für Physik, Universität Mainz, 55099 Mainz — ²Laboratoire Kastler Brossel, Département de Physique de l'ENS, Paris 75005, France

Many experiments with ultracold quantum gases are deeply influenced by atom-atom interactions. When interactions are strong enough, they can evolve an initial state without inter-particle correlations into a correlated state. This offers the opportunity for quantum state engineering of non-classical many-body states, with possible applications in quantum information or precision measurements. Here we report on the controlled manipulation of a quantum many-body state in an array of two-component quantum gases. Controllable atomic interactions are used to induce a collective dynamics which affects the quantum distribution of the relative phase between the two components. The ensuing

quantum phase dispersion is detected by monitoring the coherence properties of the system through Ramsey interferometry, showing an interaction induced collapse of the Ramsey fringe contrast. We demonstrate the coherent nature of this interaction by time-reversal of the dynamics, observing a revival of coherence in the system. Our results point towards the possibility of dynamically creating correlated spin states or even mesoscopic Schrödinger cat states, and moreover have implications on our understanding of decoherence in ultracold atomic systems.

Q 40.5 Mi 15:00 6J

Manifestation of dynamical screening in a spinor condensate — NAVEZ PATRICK — Labo Vaste-Stoffysica en Magnetisme, Katholieke Universiteit Leuven, Celestijnlaan 200 D, B-3001, Heverlee, Belgium — Fachbereich Physik, Universitaet Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg, Germany

The Landau criterion is a necessary but not sufficient condition for the occurrence of superfluidity. In particular, it ignores that the normal fluid consists of thermal excitations, some of them with a group velocity higher than the critical one. As a consequence, thermal atoms prevent dissipationless motion by colliding with the superfluid ones, unless a mechanism forbids this process. A possible mechanism is the dynamical screening of the interaction force between the thermal atoms and the superfluid ones. A local modification of the amplitude of the superfluid macroscopic wavefunction would induce a local diminution of the potential energy resulting, under some conditions, in a total screening of this interaction force. We propose an experimental setup in which the measurement of the dynamic structure factor in a spinor Bose gas could allow the visualization of this screening phenomenon.

P. Navez, *Physica A* **356**, 241 (2005); P. Navez and R. Graham, *Phys. Rev. A* **73**, 043612 (2006).

Q 40.6 Mi 15:15 6J

Spinor Bose-Einstein Kondensate in optischen Dreiecksgittern — CHRISTOPH BECKER, JOCHEN KRONJÄGER, PARVIS SOLTAN-PANAHI, SEBASTIAN SCHNELLE, SIMON STELLMER, KAI BONGS und KLAUS SENGSTOCK — Institut für Laserphysik, Universität Hamburg

Ultrakalte Quantengase in optischen Gittern sind Gegenstand intensiver Forschung. Sie bieten einerseits ideale Voraussetzungen zur Untersuchung quantenmechanischer Phänomene wie dem Mott-Isolator Übergang oder Kohärenzeigenschaften atomarer Systeme, als auch die Möglichkeit, festkörperphysikalische Fragestellungen in sehr reinen Modellsystemen studieren zu können. Wir haben an unserem Spinor BEC Experiment ein optisches Dreiecksgitter implementiert, welches erstmals Experimente in einer neuen Geometrie zulässt und insbesondere die Untersuchung magnetischer Effekte wie z.B. Spinfrustration oder mögliche Veränderungen der Grundzustandsphasen freier Spinorsysteme [1] ermöglicht. Zusätzlich ist es in unserem Aufbau möglich durch Änderung der Polarisation ein hexagonales Gitter mit magnetischer Ordnung zu erzeugen, dessen Zusammenspiel mit der intrinsischen magnetischen Wechselwirkung der Atome und der bosonisch verstärkten Dipol-Dipol-Wechselwirkung magnetische Ordnungsphänomene erwarten lässt. Erste Messungen zum Superfluid-Mott-Isolator Übergang und zur dynamischen Entwicklung in Anwesenheit periodischer Potentiale werden präsentiert.

[1] H. Schmaljohann *et al.*, *PRL* **92**, 040402, 2004

Q 40.7 Mi 15:30 6J

Thermodynamic Properties of Spinor Fermi Gases — ARISTEU LIMA¹ and AXEL PELSTER² — ¹Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — ²Fachbereich Physik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany

At first, we consider an ideal harmonically trapped Fermi gas in which the particles have the total angular momentum $F = 3/2$. For a fixed magnetization, we calculate the temperature dependence of thermodynamic quantities like heat capacity, chemical and magneto-chemical potential within a semiclassical approximation. Then we treat a weakly interacting spinor Fermi gas with contact interaction both perturbatively and non-perturbatively within a mean-field approach. In particular, we evaluate the influence of the contact interaction upon the ground state energy. Such fermionic spinor systems are important, for

example, in the context of a ^{52}Cr - ^{53}Cr boson-fermion mixture [1].

[1] R. Chicireanu et al., Phys. Rev. A **73**, 053406 (2006).