Q 43: Quantum gases (Bosons) (joint session A/Q)

Time: Thursday 10:30–12:00 Location: S HS 1 Physik

Q 43.1 Thu 10:30 S HS 1 Physik

Squeezed field path integral description of second sound in Bose-Einstein condensates — •Mir Heliassudin Ilias Seifie[1,2], Vijay Pal Singh[1,2,3], and Ludwig Mathey[1,2,3] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, 22761 Hamburg, Germany — [2]Institut für Laserphysik, Universität Hamburg, 22761 Hamburg, Germany — [3]The Hamburg Center for Ultrafast Imaging, Luruper Chaussee 149, Hamburg 22761, Germany

We propose a generalization of the Feynman path integral using squeezed coherent states by introducing a squeezing parameter into the path integral. As a result the adaptability of the theoretical model to the physical system is enhanced. Therefore, our method can be applied to any analytical and numerical approach that is based on the path integral representation. We apply this approach to the dynamics of Bose-Einstein condensates, which gives an effective low energy description that contains both a coherent field and a squeezing field. We derive the classical trajectory of this action, which constitutes a generalization of the Gross Pitaevskii equation, at linear order. We derive the low energy excitations, which provides a description of second sound in weakly interacting condensates as a squeezing oscillation of the order parameter. This interpretation is also supported by a comparison to a numerical c-field method.

Q 43.2 Thu 10:45 S HS 1 Physik

Dimensional crossover for the beyond-mean-field correction in Bose gases — •Tobias Ilg[1], Jan Kumlin[1], Luis Santos[2], Dmitry S. Petrov[3], and Hans Peter Büchler[1] — [1]Institute for Theoretical Physics III and Center for Integrated Quantum Science and Technology, University of Stuttgart, DE-70550 Stuttgart, Germany — [2]Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstr. 2, DE-30167 Hannover, Germany — [3]LPTMS, CNRS, Univ. Paris Sud, Université Paris-Saclay, 91405 Orsay, France

We present a detailed beyond-mean-field analysis of a weakly interacting Bose gas in the crossover from three to low dimensions. We find an analytical solution for the energy and provide a clear qualitative picture of the crossover in the case of a box potential with periodic boundary conditions. We show that the leading contribution of the confinement-induced resonance is of beyond-mean-field order and calculate the leading corrections in the three- and low-dimensional limits. We also characterize the crossover for harmonic potentials in a model system with particularly chosen short- and long-range interactions and show the limitations of the local-density approximation. Our analysis is applicable to Bose-Bose mixtures and gives a starting point for developing the beyond-mean-field theory in inhomogeneous systems with long-range interactions such as dipolar particles or Rydberg-dressed atoms.

Q 43.3 Thu 11:00 S HS 1 Physik

Scale-invariant dynamics of an interacting 2D Bose gas — •Raphaël Saint-Jalm, Patricia Christina Marques Castilho, Édouard Le Cerf, Jean-Loup Ville, Brice Bakkali-Hassani, Sylvain Nascimbène, Jean Dalibard, and Jérôme Beugnon — Laboratoire Kastler Brossel, Collège de France, CNRS, ENS-PSL University, Sorbonne Université, 11 place Marcelin Berthelot, 75005 Paris, France

The dynamics of an interacting many-body system is usually difficult to predict fully, but some of its features can be captured if the system has underlying symmetries such as scale invariance. Here we study the dynamics of a 2D cloud of ultracold Rubidium atoms in a harmonic potential. The many-body Hamiltonian of such a system has an exact SO(2,1) symmetry and exhibits scale-invariant properties. We produce an initial cloud strongly out of equilibrium with a uniform density and a tunable shape, and observe this scale-invariant dynamics. Moreover, in the Thomas-Fermi limit where the system can be described by hydrodynamic equations, we demonstrate an additional scale invariance. We also report on the observation of particular shapes whose evolution is periodic, which we attribute to breathers of the 2D Gross-Pitaevskii equation.

Q 43.4 Thu 11:15 S HS 1 Physik

Weakly Interacting Bose Gas on a Sphere — •Natália Móller[1], Vanderlei Bagnato[2], and Axel Pelster[1] — [1]Research Center OPTIMAS and Department of Physics, Technische Universität Kaiserslautern, Germany — [2]Institute of Physics of São Paulo, University of São Paulo, São Carlos, Brazil

Here we explore how to describe theoretically a weakly interacting Bose gas on a sphere. In order to derive the corresponding many-body field theory we start with considering a radial harmonic trap, which confines the three-dimensional Bose gas in the vicinity of the surface of a sphere. Following the notion of dimensional reduction as outlined in Ref. [1] we assume a large enough trap frequency so that the radial degree of freedom of the field operator is fixed despite of thermal and quantum fluctuations to the ground state of the radial harmonic trap and can be integrated out. With this we obtain an effective many-body field theory for a Bose-Einstein condensate on a quasi two-dimensional sphere, where the thickness of the cloud is determined self-consistently.

As a first example we determine the critical temperature of a Bose Gas on a sphere, where we recover in the limit of an infinitely large radius the case of a quasi two-dimensional plane with a vanishing critical temperature in accordance with the Mermin-Wagner theorem [2]. Afterwards, we analyze at zero temperature the mean-field physics of a Bose-Einstein condensate on a sphere by deriving the underlying time-dependent Gross-Pitaevskii equation.

[1] L. Salasnich et al., Phys. Rev. A **65**, 043614 (2002)
[2] N. Mermin and H. Wagner, Phys. Rev. Lett. **17**, 1133 (1966)

Q 43.5 Thu 11:30 S HS 1 Physik

Quantum walks of two cobosons — •Mama Kabir Njoya Mforifoum[1], Gabriel Dufour[1,2], and Andreas Buchleitner[1] — [1]Institute of Physics, Albert-Ludwigs University of Freiburg, Germany — [2]Freiburg Institute for Advanced Studies, Albert-Ludwigs University of Freiburg, Germany

A quantum walker is a particle evolving coherently over a network of sites and therefore has the ability to interfere with itself, contrary to its classical counterpart. The extension to two-particle quantum walks leads to the introduction of interactions and many-particle interference depending on the particles' statistics (bosonic or fermionic) and their distinguishability. We compare the quantum walk of two interacting cobosons (two pairs of bounded fermions) on a 1D lattice with that of two elementary bosons, and investigate to which extent the composite nature of the cobosons affects their dynamics.

Q 43.6 Thu 11:45 S HS 1 Physik

Probing the mott-insulator state in optical lattices with photoassociation collisions — •Hui Sun, Bing Yang, Zhen-sheng Yuan, and Jian-wei Pan — Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

The photoassociation collision is a process two colliding atoms form an excited molecular state after absorbing a photon, which can be used to remove doublons in optical lattices. In this work, we present the detection of a bosonic Mott-insulator state in optical lattices via photoassociation collisions. The photoassociation frequency and collision strength in the 0_g^- molecular channel are calibrated in ultracold quantum gases of Rb^{87}. Then we measure the density distributions of two-dimensional Mott-insulator states in optical lattices after illuminated by a photoassociation light, which is 13.6 cm^{-1} red detuned to the D2 line. From the density profiles, we extract the temperatures of the Mott-insulators and demonstrate an improvement of the measurement precision. This new method extends our ability to probe this ultracold strongly correlated systems.