Q 45: Quantum gases: Bosons II

Time: Thursday 11:00–12:30 Location: F 342

Q 45.1 Thu 11:00 F 342

Scattering bright solitons: quantum versus mean-field behavior — •Bettina Gertjerenken[1] and Christoph Weiss[2] — [1]Institut für Physik, Carl von Ossietzky Universität Oldenburg, D-26111 Oldenburg, Germany — [2]Department of Physics, Durham University, Durham DH1 3LE, United Kingdom

We investigate scattering bright solitons of a potential using both analytical and numerical methods. Our paper focuses on low kinetic energies for which differences between the mean-field description via the Gross-Pitaevskii equation (GPE) and the quantum behavior are particularly large. On the N-particle quantum level, adding an additional harmonic confinement leads to a simple signature to distinguish quantum superpositions from statistical mixtures. While the non-linear character of the GPE does not allow quantum superpositions, the splitting of GPE-solitons takes place only partially. When the potential strength is increased, the fraction of the soliton which is transmitted or reflected jumps non-continuously. We explain these jumps via energy-conservation and interpret them as indications for quantum superpositions on the N-particle level. On the GPE-level, we also investigate the transition from this stepwise behavior to the continuous case.

Q 45.2 Thu 11:15 F 342

Roton confinement in a trapped dipolar Bose-Einstein condensate — Mattia Jona Lasinio, •Kazimierz Łakomy, and Luis Santos — Institut für Theoretische Physik, Leibniz Universität, Hannover, Appelstrasse 2, D-30167 Hannover, Germany

Roton-like excitations constitute the key feature of dipolar gases, linking these systems to superfluid Helium. We show that the inherent locality of the roton spectrum in a trapped dipolar condensate results in the spatial confinement of rotons. As a result, roton instability leads to the appearance of localized density patterns which, depending on parameters of the system and fluctuations, can acquire the form of concentric rings. The localized modulational instability gives rise to a peculiar post-collapse dynamics which lacks the typical d-wave symmetry, characteristic for the global collapses in a dipolar condensate. Moreover, induced roton instability may be employed to create a gas of trapped roton excitations, with characteristic persistent density modulations confined in the center of the trap. Other consequences of the local roton spectrum are also discussed, including local susceptibility against a perturbation of the condensate, which leads to an inhomogeneous vortex lattice.

Q 45.3 Thu 11:30 F 342

Particles, holes and solitons: a matrix product state approach — •Tobias Osborne[1], Damian Draxler[2], Jutho Haegeman[3], Vid Stojevic[2], Laurens Vanderstraeten[3], and Frank Verstraete[2] — [1]Leibniz Universität Hannover, Institute of Theoretical Physics and Riemann center for geometry and physics, Appelstrasse 2, D-30167 Hannover, Germany — [2]Vienna Center for Quantum Science, Universität Wien, Boltzmanngasse 5, A-1090 Wien, Austria — [3]Ghent University, Department of Physics and Astronomy, Krijgslaan 281- S9, B-9000 Ghent, Belgium

We introduce a variational method for calculating dispersion relations of translation invariant (1+1)-dimensional quantum field theories. The method is based on continuous matrix product states and can be implemented efficiently. We study the Lieb-Liniger model as a benchmark where, despite criticality, excellent agreement with the exact solution is found, including, clear solitonic effects in Lieb's Type II excitation. In addition, a non-integrable model is studied where a U(1)-symmetry breaking term is added to the Lieb-Liniger Hamiltonian. For this model we find evidence of a non-trivial bound-state excitation in the dispersion relation.

Q 45.4 Thu 11:45 F 342

Compact mixture of degenerate quantum gases — •Katerine Posso-Trujillo, Holger Ahlers, Ernst M. Rasel, and Naceur Gaaloul — Institut für Quantenoptik, Leibniz Universität Hannover

Recent proposals in atom optics rely on long-lived samples of ultra-cold matter. Having compact sources (no more than mm range in radius) is necessary to prevent decoherence over long times and more strictly dephasing due to the spatial extension of the sample. A possible solution is to use the δ-kick technique to collimate the expanding BEC source, however this technique has to be adapted to the case of a quantum mixture.

During this talk, we will provide a clear method for preparing a mixture of ^{85}Rb/^{87}Rb which stays compact for several seconds.

The recipe includes the production of a miscible and stable mixture of the two Rb isotopes. The δ-kick cooling of both with realistic parameters of magnetic fields used, and laser beams.

Q 45.5 Thu 12:00 F 342

Solitonic states far from equilibrium — •Sebastian Erne[1,2], Boris Nowak[1,2], and Thomas Gasenzer[1,2] — [1]Institut für Theoretische Physik, Ruprecht-Karls-Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, 64291 Darmstadt, Germany

The dynamics of an ultracold Bose gas far from equilibrium in one spatial dimension is analysed in the context of quasi-stationary solitonic states. We analytically describe the state within a model of randomly distributed solitons and address the possibilities for new experimental observations via statistical simulations using the classical field equations. Focus is placed on the one particle momentum distribution, concerning the appearance of transient power-laws, characteristic multi-peak structures for small momenta in a finite size system, and it's measurement in focus through the free expansion of the gas. Further, the influence of solitons on the density-density correlation after free expansion are addressed. Different scenarios including an anharmonicity of the trapping potential and the influence of temperature in the quasi-condensate regime are discussed. The results give detailed insight into the dynamics of solitons in these systems.

Q 45.6 Thu 12:15 F 342

A novel experiment for coupling quantum gases to various optical cavities — •Julian Leonard, Moonjoo Lee, Leigh Martin, Christian Zosel, Tilman Esslinger, and Tobias Donner — Institut for Quantum Electronics

We present the design and current status of a novel experimental system aiming at coupling a Bose-Einstein condensate (BEC) to optical cavities. At the heart of the apparatus is an interchangeable science platform which can house the cavities as well as a lens for high-resolution imaging of the atoms. This platform can be rapidly inserted into the vacuum chamber through a loadlock chamber, from which it is transferred into a vibration-isolated docking station. There we have excellent optical, thermal and electrical access from the outside while maintaining high stability and reproducibility in position.

The BEC is generated from a cloud of laser-cooled 87-Rb atoms which is first loaded into a hybrid trap and then optically transported into the cavity setup. Here it is transferred into a crossed dipole trap and evaporatively cooled down to quantum degeneracy.

This novel approach opens up the possibility to use a single apparatus to study the coupling of quantum gases with various cavity geometries such as crossed cavities, multimode cavities or setups involving mechanical membranes. With these systems, we aim to explore the dynamics of ultracold atoms in self-generated optical potentials, where novel phases of matter and light are predicted to appear.