Q 42: Quantum gases: Disorder- or interaction-induced effects

Time: Thursday 14:00–15:30 Location: UDL HS2002

Group Report Q 42.1 Thu 14:00 UDL HS2002

Perturbative and Non-Perturbative Methods for Tackling the Dirty Boson Problem — •Axel Pelster — Fachbereich Physik und Forschungszentrum OPTIMAS, Technische Universität Kaiserslautern, Germany

The notoriously difficult *dirty boson problem* amounts to understanding the emergence of coherence and order for ultracold bosonic atoms in the presence of a quenched disorder potential. It appears either naturally like in current carrying wire traps, or artificially like in laser speckle fields. Theoretically it is intriguing because of the competition of localization and interaction as well as of disorder and superfluidity.

We start with solving perturbatively the coupled hydrodynamic equations for a homogeneous BEC with a weak disorder potential. In this way we reproduce the explicit expressions of Huang and Meng for the disorder corrections of both condensate and superfluid density. In addition, we consider a 1d ring trap and determine how the superfluid velocity depends on the disorder correlation length.

Afterwards, we compare two non-perturbative methods, where the first one is based on a Hartree-Fock mean-field theory by invoking replica symmetry and the second one follows from a Gaussian approximation for correlation functions. For a homogeneous BEC we find for strong disorder a quantum phase transition from a superfluid to a Bose-glass phase whose order changes from second to first order for increasing disorder correlation length. Furthermore, we determine for a harmonically trapped BEC the respective density profiles of both the global condensate and the fragmented BECs for Lorentzian disorder.

Q 42.2 Thu 14:30 UDL HS2002

Phonon-mediated interaction of slow-light polaritons in a BEC — •Hanna-Lena Haug and Michael Fleischhauer — Department of Physics and research center OPTIMAS, University of Kaiserslautern, Germany

We study the dynamics of dark-state polaritons (DSP) in a Bose-Einstein condensate. DSPs are formed in an atomic ensemble interacting in a Λ-type configuration with two light fields under conditions of electromagnetically induced transparency. We consider a BEC of ground-state atoms which interact with the meta-stable spin-state of the Λ-System. This gives rise to an effective interaction between the DSPs, mediated by the Bogoliubov phonons of the BEC as well as to a dissipative mechanism. We analyze how the momentum distribution of the DSPs is modified by this interaction and show that it provides a mechanism for cooling DSPs. We find that the effective mass of the DSPs in the BEC increases, indicating a formation of polarons. Moreover we discuss how the phonon-mediated scattering between two DSPs can be used to create a phase gate for photons. Our analysis shows that a phase shift of π can be realized with our protocol using current experimental technology.

Q 42.3 Thu 14:45 UDL HS2002

Faraday Waves in Collisionally Inhomogeneous Bose-Einstein Condensates — •Antun Balaž[1], Remus Paun[2], Alexandru Nicolin[3], Sudharsan Balasubramanian[3], and Radha Ramaswamy[3] — [1]Scientific Computing Laboratory, Institute of Physics Belgrade, University of Belgrade, Serbia — [2]Horia Hulubei National Institute of Physics and Nuclear Engineering, Bucharest, Romania — [3]Government College for Women, Kumbakonam, India

We study the emergence of Faraday waves in quasi-one-dimensional collisionally inhomogeneous Bose-Einstein condensates subject to periodic modulation of the radial confinement. Considering a Gaussian-shaped radially inhomogeneous scattering length, we show through extensive numerical simulations and detailed variational treatment that the period of the emerging Faraday waves increases as the inhomogeneity of the scattering length gets weaker, and saturates once the width of the radial inhomogeneity reaches the radial width of the condensate. We also show that when the modulation frequency is close to the trap radial frequency, the condensate exhibits resonant waves accompanied by excitation of collective modes, while for frequencies close to twice that of the trap radial frequency, the observed Faraday waves set in forcefully and quickly destabilize condensates with weakly inhomogeneous two-body interactions, unlike in the case of homogeneous interactions [1].

[1] A. Balaž and A. I. Nicolin, Phys. Rev. A **85**, 023613 (2012).

Q 42.4 Thu 15:00 UDL HS2002

Localization of Bogoliubov excitations — •Christopher Gaul[1], Pierre Lugan[2], and Cord A Müller[3] — [1]Max-Planck-Institut für Physik Komplexer Systeme, D-01187 Dresden — [2]Laboratory of Theoretical Physics of Nanosystems, Ecole Polytechnique Fédérale de Lausanne, CH-1015 Lausanne, Switzerland — [3]Fachbereich Physik, Universität Konstanz, D-78457 Konstanz

We study the localization of Bogoliubov excitations of disordered Bose-Einstein condensates in one-dimensional and quasi–one-dimensional geometries. We present numerical results for the localization length based on a transfer-matrix approach and finite-size scaling. We discuss the results as function of the excitation energy and confront them with analytical results [Gaul & Müller, Phys. Rev. A 83, 063629 (2011)] on the scattering mean free path and the transport mean free path.

Q 42.5 Thu 15:15 UDL HS2002

Dynamics and propagation of light in an interacting Rydberg-EIT medium — •Dario Jukić, Callum Murray, and Thomas Pohl — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden

We study the nonlinear propagation of light in an interacting cold Rydberg gas under conditions of electromagnetically induced transparency (EIT). In the limit of low probe-beam intensities we derive an analytical expression for the nonlinear susceptibility that takes into account the nonlocal character of the optical response both in space and in time. This not only leads to effective photon interactions but also to nonlinearities in the photonic group velocity and masses. We illustrate these effects by analyzing the propagation dynamics of light pulses and discuss observable consequences.