Q 27: Quantum gases: Bosons II

Time: Tuesday 14:00–16:00 Location: UDL HS2002

Q 27.1 Tue 14:00 UDL HS2002

Repulsive to attractive interaction quenches for bosons in a one-dimensional trap — •Wladimir Tschischik, Roderich Moessner, and Masud Haque — Max-Planck-Institut für Physik komplexer Systeme, Dresden, Germany

We present a study of the non-equilibrium dynamics of attractively interacting bosons in a one-dimensional harmonic trap. We describe the physics in terms of many-body spectra. We focus on the highly excited 'super-Tonks-Girardeau' state that is accessed through a sudden quench from a positive to a negative interaction. We describe both lattice (Bose-Hubbard) and continuum (Lieb-Liniger) cases.

Q 27.2 Tue 14:15 UDL HS2002

Optimal persistent currents for ultracold bosons stirred on a ring — Marco Cominotti[1], Davide Rossini[2], •Matteo Rizzi[3], Frank Hekking[1], and Anna Minguzzi[1] — [1]Université Grenoble 1/CNRS, Laboratoire de Physique et de Modélisation des Milieux Condensés (UMR 5493), B.P. 166, 38042 Grenoble, France — [2]NEST, Scuola Normale Superiore and Istituto Nanoscienze-CNR, I-56126 Pisa, Italy — [3]Johannes Gutenberg-Universität Mainz, Institut für Physik, Staudingerweg 7, D-55099 Mainz, Germany

We study persistent currents for interacting bosons on a tight ring trap, subjected to an artificial gauge field induced by a rotating barrier potential. To cover all interaction and barrier strength regimes, we employ a combination of analytical and numerical approaches. The first include Gross-Pitaevskii (GP) theory at weak interactions, the Luttinger-liquid (LL) model at intermediate ones, and the Tonks-Girardeau (TG) solution in the impenetrable boson limit. The numerics is based on a variational technique over a periodic-boundary matrix-product-state (MPS-PBC) representation of the system wavefunction.

As a main result, we show that at intermediate interactions the persistent current response is maximal, due to a subtle interplay of effects due to the barrier, the interaction and quantum fluctuations. These results are relevant for ongoing experiments with ultracold atomic gases on mesoscopic rings, as well as for thin superconducting rings and solid-state photonic or polaritonic nanocavities etched on a ring-necklace shape.

[1] arXiv:1310.0382v1

Q 27.3 Tue 14:30 UDL HS2002

Stability of a dissipative Bose-Hubbard trimer — Steffen Wolf[1] and •Sandro Wimberger[1,2] — [1]Institut für Theoretische Physik, Universität Heidelberg, Deutschland — [2]Dipartimento di Fisica e Science della Terra, Università di Parma, Via G.P. Usberti 7/a, I-43124 Parma

Ultra cold atoms in optical traps form strongly correlated quantum states which can be prepared using particle loss. Preparation methods with localized particle loss were proposed in [1].

In this talk, we analyze the stability of quantum states in a three-site optical lattice with delocalized atom loss. Analytical solutions in the non-interaction-limit yield decoherence-free subspaces, the size of which increases with the number of atoms. Numerical simulations for interacting particles in these subspaces show different types of loss reduction. High loss rates lead to a stabilization of the states due to the Quantum-Zeno effect. For every interaction strength we find a quantum state with strongly reduced loss probability that transforms from a superluid to a Fock state with increasing interaction.

[1] G. Kordas, S. Wimberger, and D. Witthaut, *Dissipation-induced macroscopic entanglement in an open optical lattice*, EPL **100**, 3000 (2012).

Q 27.4 Tue 14:45 UDL HS2002

Quantum-Zeno effect in an one-dimensional optical lattice with localized dissipation — •Ralf Labouvie, Andreas Vogler, Simon Heun, Bodhaditya Santra, and Herwig Ott — Fachbereich Physik and Research Center OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

In our experiment we investigate the dynamics of an out-of-equilibrium system under the influence of localized particle loss. At the beginning we prepare a 87Rb Bose-Einstein-Condensate (BEC) which is loaded into an one-dimensional optical lattice. We start the experiment by removing all atoms from one of the central sites with the help of a tightly focused electron beam. After preparing this non-equilibrium state we allow for refilling dynamics while continuously probing the emptied site with the electron beam. The ionized atoms are detected and thus allow us to measure the time evolution of the system. We observe the complete suppression of tunneling at high dissipation rates which can be explained by means of a dissipation-induced Quantum-Zeno-effect.

Q 27.5 Tue 15:00 UDL HS2002

Two-dimensional superfluidity in driven systems requires strong anisotropy — Ehud Altman[1], John Toner[2], •Lukas M. Sieberer[3,4], Sebastian Diehl[3,4], and Leiming Chen[5] — [1]Department of Condensed Matter Physics, Weizmann Institute of Science, Rehovot 76100, Israel — [2]Department of Physics and Institute of Theoretical Science, University of Oregon, Eugene OR, 97403, U.S.A. — [3]Institute for Theoretical Physics, University of Innsbruck, A-6020 Innsbruck, Austria — [4]Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, A-6020 Innsbruck — [5]College of Science, The China University of Mining and Technology, Xuzhou Jiangsu, 221116, P.R. China

We show that driven two-dimensional Bose systems cannot exhibit algebraic superfluid order unless the underlying microscopic system is strongly anisotropic. Our result implies, in particular, that recent apparent evidence for Bose condensation of exciton-polaritons in semiconductor quantum wells must be an intermediate scale crossover phenomenon, while the true long distance correlations fall off exponentially. We obtain these results through a mapping of the long-wavelength condensate dynamics onto the anisotropic Kardar-Parisi-Zhang equation.

Q 27.6 Tue 15:15 UDL HS2002

Noise correlations of two-dimensional Bose gases — •Vijay Pal Singh and Ludwig Mathey — Zentrum für Optische Quantentechnologien and Institut für Laserphysik, Universität Hamburg, D-22761 Hamburg, Germany

We analyze density-density correlations of expanding clouds of weakly interacting two-dimensional Bose gases below and above the Berezinskii-Kosterlitz-Thouless (BKT) transition [1, 2], with particular focus on short-time expansions. During time-of-flight expansion, phase fluctuations of the trapped system translate into density fluctuations. We calculate the correlations of these fluctuations both in real space and in momentum space, and derive analytic expressions in momentum space. Below the transition, the correlation functions show an oscillatory behavior, controlled by the scaling exponent of the quasi-condensed phase, due to constructive interference. We argue that this can be used to extract the scaling exponent of the quasi-condensate experimentally. Above the transition, the interference is rapidly suppressed when the atoms travel an average distance beyond the correlation length. This can be used to distinguish the two phases qualitatively.

References:
[1] V. L. Berezinskii, Sov. Phys. JETP 34, 610 (1972).
[2] J. M. Kosterlitz and Thouless, J. Phys. C 6, 1181 (1973).

Q 27.7 Tue 15:30 UDL HS2002

Quench Dynamics near a Quantum Phase Transition in a Two-Component Bose Gas — •Markus Karl[1,2], Aisling Johnson[2,3], Eike Nicklas[2,3], Markus Oberthaler[2,3], 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, Planckstraße 1, 64291 Darmstadt, Germany — [3]Kirchhoff-Institute for Physics, Ruprecht-Karls-Universität Heidelberg, Im Neuenheimer Feld 227, 69120 Heidelberg

We present a numerical analysis of the dynamics ensuing sudden quenches in a two-component, linear and non-linear coupled Bose gas. Starting from different initial configurations we study quenches in both, linear and non-linear, coupling parameters which end near, either below or above, the equilibrium quantum critical point. At the latter the equilibrium ground state changes from miscible to immiscible. Concentrating on the relative degrees of freedom which are represented in terms of spins, we discuss the time evolution of spin spectra and spin correlation lengths after the quench as a function of the distance to the critical point. We present numerical evidence that the non-equilibrium dynamical system is subject to self-similarity in time and space as a function of the distance to the equilibrium critical point, characterised by scaling exponents similar to the equilibrium phase transition. The presented results confirm recent experimental findings for a quasi-1D Rubidium-87 gas.

Q 27.8 Tue 15:45 UDL HS2002

Kinetic frustration in shaken optical lattices — •Albert Verdeny[1,2] and Florian Mintert[1,2] — [1]Freiburg Institute for Advanced Studies, Albert-Ludwigs-University, 79104 Freiburg, Germany — [2]Department of Physics, Imperial College London, London SW7 2AZ, United Kingdom

We investigate the impact of geometry on the effective Hamiltonian of shaken lattices. In specific geometries like the hexagonal or kagome lattice, new next-nearest-neighbor tunneling that is not present in the undriven Hamiltonian appears. We show how an appropriate choice of periodic driving can conveniently enhance or suppress these terms, which opens new possibilities for the study of frustration in such systems.