Q 46: Quantum Gases: Bosons V

Time: Thursday 11:00–12:45 Location: e001

Q 46.1 Thu 11:00 e001

Ground-State Properties of Anyons in a One-Dimensional Lattice — •Guixin Tang[1], Sebastian Eggert[2], and Axel Pelster[2] — [1]Physics Department, Harbin Institute of Technology, China — [2]Physics Department and Research Center OPTIMAS, Technische Universität Kaiserslautern, Germany

Using the Anyon-Hubbard Hamiltonian, we analyze the ground-state properties of anyons in a one-dimensional lattice [1]. To this end we map the hopping dynamics of correlated anyons to an occupation-dependent hopping Bose-Hubbard model using the fractional Jordan-Wigner transformation. In particular, we calculate the quasi-momentum distribution of anyons, which interpolates between Bose-Einstein and Fermi-Dirac statistics. Analytically, we apply a modified Gutzwiller mean-field approach, which goes beyond a classical one by including the influence of the fractional phase of anyons within the many-body wavefunction. Numerically, we use the density-matrix renormalization group by relying on the ansatz of matrix product states. As a result it turns out that the anyonic quasi-momentum distribution reveals both a peak-shift and an asymmetry which mainly originates from the nonlocal string property. In addition, we determine the corresponding quasi-momentum distribution of the Jordan-Wigner transformed bosons, where, in contrast to the hard-core case, we also observe an asymmetry for the soft-core case, which strongly depends on the particle number density.

[1] G. Tang, S. Eggert, and A. Pelster, New J. Phys. (in press), `arXiv:1509.01888`

Q 46.2 Thu 11:15 e001

Anyons in 1D optical lattices by time periodic forcing — •Christoph Sträter[1], Shashi C. L. Srivastava[1,2], and André Eckardt[1] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden, Germany — [2]Variable Energy Cyclotron Centre, 1/AF Bidhan nagar, Kolkata, India 700 064

Interpolating between bosons and fermions, anyons are particles that pick up a complex phase $0 < \theta < \pi$ upon particle exchange. In one dimensional optical lattices, where anyons can be mapped onto bosons with a density dependent complex hopping element, the possible realization and the physics of anyons has caught a lot of interest recently. Still, the experimental implementation has not yet been achieved. We propose a simple scheme to realize 1D anyons in optical lattices that relies only on lattice shaking and tilting. Within our proposal, also the on-site interaction of the anyons can be tuned effectively. We analyze the ground state of a chain of finite length, as it can be realized in a quantum gas microscope. With increasing θ the atoms tend to localize and to form a crystal-like structure. This is a signature of the smooth fermionization and can be observed in the density, in two-particle correlations, and in the 2nd Renyi entropy of subsystems.

Q 46.3 Thu 11:30 e001

Spectral characterization of two-dimensional Bose-Hubbard models — •David Fischer[1], Darius Hoffmann[1], and Sandro Wimberger[1,2,3] — [1]Institut für Theoretische Physik, Universität Heidelberg, 69120 Heidelberg, Germany — [2]Dipartimento di Fisica e Scienze della Terra, Università degli Studi di Parma, Via G. P. Usberti 7/a, 43124 Parma — [3]INFN, Sezione di Milano Bicocca, Gruppo Collegato di Parma, Italy

We study the spectral properties of simple Bose Hubbard models in two dimensions. Small finite size lattices are analyzed for different boundary conditions and different geometries. As we will show, the chosen geometry determines the level-spacing-statistics, which we investigate numerically for all symmetry-reduced subspaces of the Hamiltonian matrix. By comparison of both next-neighbor statistics and long-range spectral correlation functions with the predictions from Random-Matrix Theory (RMT), we find that most setups enjoy quantum chaotic behavior in a certain regime of parameters. This coincides with previous results for one-dimensional systems. Increasing the number of bonds in the lattice results in a smooth transition to a more regular behavior over the whole parameter range. Our spectral results allow us to control the systems' dynamics in a desired way by the choice of the specific form of the lattice and its bonds. Moreover, our investigations may enable further studies of quantum many-body chaos, which is becoming more and more relevant also for state-of-the-art experiments with ultracold bosons in optical lattices.

Q 46.4 Thu 11:45 e001

Quantum transport of ultra-cold bosons in optical lattices — •Urs Waldmann[1,2], Alberto Rodriguez[1], Sandro Wimberger[2,3], and Andreas Buchleitner[1] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, 79104 Freiburg, Germany — [2]Dipartimento di Fisica e Scienze della Terra, Università degli Studi di Parma, 43124 Parma, Italy — [3]INFN, Sezione di Milano Bicocca, Gruppo Collegato di Parma, Italy

We develop a theoretical framework for the description of experiments on quantum transport of ultra-cold bosons across one-dimensional lattices. We imagine a finite-length lattice connected to reservoirs, which we model by a single-band Bose-Hubbard Hamiltonian with a finite number of sites, connected to some input and output leads. We present first results (obtained by exact diagonalisation) on non-equilibrium dynamics on the closed chain, and on the particle current which can be induced by a finite coupling strength to the leads.

Q 46.5 Thu 12:00 e001

Bose-Einstein condensation in frustrated optical lattices — •Ludwig Mathey[1], Peter Janzen[1], and Wen-Min Huang[2] — [1]ZOQ/ILP, Universität Hamburg, Hamburg, Germany — [2]National Chung-Hsing University, Taichung, Taiwan

We explore the critical behavior of Bose-Einstein condensation in frustrated lattices. In these lattices, an additional, chiral symmetry emerges, which is spontaneously broken at low temperatures. We discuss how this broken symmetry has been experimentally detected via interference of two independent chiral condensates. Furthermore, we present the critical behavior of these systems that are obtained within a renormalization group approach.

Q 46.6 Thu 12:15 e001

Interacting bosons on two-leg ladders in magnetic fields — •Sebastian Greschner[1], Marie Piraud[2], Fabian Heidrich-Meisner[2], Ulrich Schollwöck[2], Ian McCulloch[3], and Temo Vekua[1] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover, Germany — [2]Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München — [3]ARC Centre, University of Queensland

Ultra-cold bosons in ladders with an externally applied synthetic magnetic field exhibit a surprisingly rich physics and a wealth of quantum phases for different interaction strengths. In the regime of hardcore repulsive bosons we observe Meissner and vortex liquid phases both in the superfluid and in the Mott insulator regime [1]. For the case of moderate and weak interaction strengths [2] we show how additionally for certain commensurate vortex-densities vortex-lattice phases form and a superfluid phase with spontaneously imbalanced particle number between the legs of the ladder, the so-called biased leg phase, emerges. The vortex-lattice phases with a spontaneously broken translational symmetry may exhibit a characteristic and counter-intuitive many-body feature: At sufficiently low temperatures for weak interactions strengths the edge current may reverse its direction.

[1] M. Piraud, et al., Phys. Rev. B 91, 140406(R), 2015.
[2] S. Greschner, et al., Phys. Rev. Lett. 115, 190402, 2015.

Q 46.7 Thu 12:30 e001

Effects of multi-color intensity modulations on a 1D optical lattice — •Lorenzo Cardarelli, Sebastian Greschner, and Luis Santos — Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstr. 2, DE-30167 Hannover, Germany

We study an effective model of a one-dimensional optical lattice loaded with bosonic particles of different spin components, in the presence of a multi-color modulation of the lattice intensity. The modulation opens interesting possibilities of control on the properties of the system, including effective controllable interactions without the need of Feshbach resonances and an effective two-body hard-core constraint. Furthermore, considering a ladder-like lattice in synthetic dimensions, modulation results in a hopping along the real direction (both in amplitude and in phase) that paves the way to the observation of density-dependent synthetic magnetism, along with the generation of inter-site interactions along the real direction without the need of dipolar interactions.