Q 12: Quantum Gases: Bosons II

Time: Monday 14:30–16:30 Location: P/H2

Q 12.1 Mon 14:30 P/H2

Dynamics of Bose-Einstein condensates in a one-dimensional correlated disorder potential — •Juan Pablo Ramírez Valdes[1], Andreas Buchleitner[1,2], and Thomas Wellens[1] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Herman-Herder-Str. 3, 79104 Freiburg, Germany — [2]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität, Albertstr. 19, 79104 Freiburg

We study the expansion of an initially confined one-dimensional Bose-Einstein condensate in a weak random potential with finite correlation length. At long times, the expansion comes to a halt due to destructive interferences leading to Anderson Localization [1]. We develop an improved analytical description of the asymptotic disorder-averaged condensate density, which we compare to the results of numerical simulations based on a finite-element discrete variable representation. In particular, we thereby analyze the influence of inter-atomic interactions on the localization properties.

[1] L. Sanchez-Palencia, D. Clément, P. Lugan, P. Bouyer, G. V. Shlyapnikov, and A. Aspect, Phys. Rev. Lett. **98**, 210401 (2007).

Q 12.2 Mon 14:45 P/H2

Growing bosonic Laughlin states in a lattice — Fabian Grusdt[1,2], •Fabian Letscher[1], Mohammad Hafezi[3,4], and Michael Fleischhauer[1] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Gottlieb-Daimler-Strasse 47, 67663 Kaiserslautern, Germany — [3]Joint Quantum Institute, NIST/University of Maryland, College Park, Maryland 20742, USA — [4]ECE Department and Institute for Research in Electronics and Applied Physics, University of Maryland, College Park, Maryland 20742, USA

We present a scheme for the preparation of highly correlated Laughlin states in bosonic lattice systems. The scheme is based on the idea of growing such states by adding weakly interacting composite fermions along with magnetic flux quanta one by one. The topologically protected Thouless pump is used to create two localized flux quanta resulting in a hole excitation, which is subsequently filled by a single boson using a coherent pump. A single boson together with one flux quantum forms a composite fermion. Using our protocol, filling $\nu = 1/2$ Laughlin states can be grown in a time increasing linearly with the particle number N and strongly suppressed number fluctuations. Furthermore, we analyse the scaling of the fidelity with particle number N, including particle loss and nonadiabatic transitions. We present exact numerical simulations in small lattice systems to show the feasibility of our scheme.

Q 12.3 Mon 15:00 P/H2

Twisted superfluidity in optical lattices — •Ole Jürgensen, Klaus Sengstock, and Dirk-Sören Lühmann — Institut für Laserphysik, Universität Hamburg

An unconventional quantum phase with a complex order parameter has been observed recently in a hexagonal optical lattice [1] but still lacks a conclusive theoretical understanding. We show how correlated pair tunneling in the extended Bose-Hubbard model can drive the transition to this *twisted* superfluid phase. We present the full phase diagram showing a multitude of quantum phases including checkerboard insulators, supersolids and pair superfluids. Furthermore, off-site interactions support dimerized insulator phases where particles are delocalized on several lattice sites. For two components we find twisted superfluid phases already for surprisingly small pair-tunneling amplitudes. Interestingly, this ground state shows an infinite degeneracy ranging continuously from a supersolid to a twisted superfluid.

[1] P. Soltan-Panahi *et al.*, Nature Physics 8, 71 (2012).

Q 12.4 Mon 15:15 P/H2

Bose-Hubbard ladder subject to effective magnetic field: geometry and dynamics — •Wladimir Tschischik, Roderich Moessner, and Masud Haque — Max Planck Institute for the Physics of Complex Systems, Dresden

Motivated by a recent experimental realization of an optical lattice system with an effective magnetic field (Atala et al., Nature Physics 10, 588 (2014)), we study a Bose-Hubbard system on a two-leg ladder with complex hopping amplitudes. This system shows a quantum phase transition already without interactions. We examine and present differences between the periodic, open-boundary, and harmonically trapped cases. We present a striking "slowing down" effect in the collective mode dynamics near the phase transition.

Q 12.5 Mon 15:30 P/H2

Faraday Waves in Dipolar Bose-Einstein Condensates — Dušan Vudragović and •Antun Balaž — Scientific Computing Laboratory, Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

We study the emergence of Faraday waves in quasi-one-dimensional dipolar Bose-Einstein condensates of ^{52}Cr and ^{164}Dy subject to periodic modulation of the radial confinement. We investigate through extensive numerical simulations and detailed variational treatment the effects of the strong dipolar interaction on the spatial period of the Faraday waves. Unlike in the case of homogeneous [1] or inhomogeneous contact interactions [2], the emergence of Faraday waves is found to further destabilize the condensate in the presence of strong dipolar interaction. The interesting effect of spatial period doubling of generated density patterns is observed numerically and studied within the Gaussian variational approach.

[1] A. Balaž and A. I. Nicolin, Phys. Rev. A **85**, 023613 (2012).
[2] A. Balaž, R. Paun, A. I. Nicolin, S. Balasubramanian, and R. Ramaswamy, Phys. Rev. A **89**, 023609 (2014).

Q 12.6 Mon 15:45 P/H2

Ground states for the Bose-Hubbard model with flat bands — •Petra Pudleiner[1] and Andreas Mielke[2] — [1]Institute of Physics, Johannes Gutenberg University, Mainz, Germany — [2]Institute for Theoretical Physics, Ruprecht-Karls University, Heidelberg, Germany

Flat band systems have been studied intensively in experiment and theory. They are a prototype for strongly correlated systems. Especially for bosons in a flat band, several interesting questions arise: What is the nature of the ground state? Are there regions in phase space where one can see a Bose transition?

The Bose-Hubbard model is used to visualize low energies on two-dimensional lattices which exhibit a lowest flat energy band. Up to the critical lattice filling constant, an eigenstate of the aforementioned band can be constructed by means of the charge density wave (CDW) as many-body ground state. Huber and Altman [1] explored ground states in the vicinity of the critical filling on the kagome lattice via a mean-field calculation; however, by restricting the calculation to a weakly interacting Hamiltonian.

The purpose of this talk is, firstly, to present similar results which are obtained by transferring their methods to the checkerboard lattice and, secondly, to demonstrate initial steps to extend to strong interactions. In this regard, one boson is added to the well-known ground state. The distribution of this additional particle seems to be localized, in contrast to the weakly interacting limit; here we observe a Bose condensation.

[1] S. Huber and E. Altman, PRB 82, 184502 (2010)

Q 12.7 Mon 16:00 P/H2

Realistic matter-wave interferometry with non-unitary operators — •Luis Fernando Barragán-Gil and Reinhold Walser — Institut für angewandte Physik, Technische Universität Darmstadt, Hochschulestr. 4a, 64289 Darmstadt

The realization of Bose-Einstein condensates in μ-gravity conditions, at the ZARM drop tower in Bremen by the QUANTUS collaboration [1,2] , has opened the possibility to measure corrections to local gravitational field of the Earth beyond the linear Earth's acceleration (g) [3,4]. This is known as the gravity gradient correction and it is the next dominant contribution found in classical Newtonian Physics as well as in general relativistic view of gravity.

We use thermal ensembles and non-unitary operator formalism [5] (particle loss, temperature, realistic detector) to implement an atom interferometer in the presence of the harmonic corrections to the gravitational potential, and look for the effects of misalignment and temperature on the fringe pattern.

[1] Quantus Collaboration *http://www.iqo.uni-hannover.de/quantus.html*

[2] van Zoest, T. et al. *Bose-Einstein Condensation in Microgravity*, Science, **328**, 1540-1543 (2010)
[3] Dimopoulos, S. et al. *General Relativistic effects in atom interferometry*, Phys. Rev. D, **78** 042003 (2008)
[4] Kasevich, M. A. and Chu, S. *Atom Interferometry Using Stimulated Raman Transitions*, Phys. Rev. D, **67**, 181-184 (1991)
[5] Balian, R. and Brezin, E. *Nonunitary Bogoliubov Transformations and Extension of Wick's Theorem* Nuovo Cimento, LXIV B, 1 (1969)

Q 12.8 Mon 16:15 P/H2

Bose Polaron in a Harmonic Trap — •Artem Volosniev[1,2], Hans-Werner Hammer[2], and Nikolaj Zinner[1] — [1]Aarhus University, Aarhus 8000, Denmark — [2]TU Darmstadt, Darmstadt, Germany

The study of an ideal system with an impurity dates back to the dawn of quantum theory. This so-called polaron problem has allowed physicists to develop sophisticated mathematical tools for many-body problems that in turn were used to gain insight in both static and dynamics properties of systems with impurities. Originally formulated in condensed matter physics this problem has become a hot topic in the community working on cold atomic gases.

In this contribution we present a field-theoretical study of an impurity immersed in an ideal harmonically trapped Bose Gas at zero temperature. A method to calculate the Green's function in space-time and momentum-time domain is developed for times much smaller than the time scale set by the external trap. Comparing these functions with the solutions for the homogeneous case the effect of an external trap is discussed.