Q 44: Quantum Gases: Miscellaneous

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

Group Report Q 44.1 Wed 14:30 P/H2

A single neutral atom impurity in an ultracold Bose gas — •Farina Kindermann, Michael Bauer, Tobias Lausch, Daniel Mayer, Felix Schmidt, and Artur Widera — TU Kaiserslautern, FB Physik, Erwin-Schrödinger-Str. 46, 67663 Kaiserslautern

Recently hybrid systems of single particles immersed in a many body system have been a subject of intense interest to study, e.g. impurity-bath interactions. We report on an experiment to combine an ultracold Rb87 cloud with a single neutral Cesium atom. The experimental apparatus features a short cycle time, facilitated by an evolutionary algorithm optimizing various processes in the experimental cycle. Controlled doping of the cloud can be achieved with a species selective lattice which has an almost zero potential for the Rb cloud but at the same time serves as a conveyor belt for the Cs atoms. We will focus on the dynamics of single atoms in a 1D lattice driven by an optical molasses and on the combination of single atoms with the ultracold gas.

Q 44.2 Wed 15:00 P/H2

Trapped Bose-Einstein Condensates with Strong Disorder — •Antun Balaž[1] and Axel Pelster[2] — [1]Scientific Computing Laboratory, Institute of Physics Belgrade, University of Belgrade, Serbia — [2]Physics Department and Research Center OPTIMAS, Technische Universität Kaiserslautern, Germany

We work out a non-perturbative approach towards the dirty boson problem at zero temperature which is based on a Gaussian approximation for correlation functions of the disorder problem and the condensate wave function solving the Gross-Pitaevskii problem. For the homogeneous case we obtain a set of self-consistency equations for correlation functions which can be solved for general disorder numerically but allows an analytic solution in case of delta-correlated disorder. Afterwards, we apply the Thomas-Fermi approximation and generalize these self-consistency equations for a harmonically trapped Bose-Einstein condensate. With this we obtain results which reproduce for weak disorder the seminal results of a Bogoliubov theory of dirty bosons [1-3] and yield a quantum phase transition to a Bose-glass phase for strong disorder [4].

[1] K. Huang, H.-F. Meng, Phys. Rev. Lett. **69**, 644 (1992)
[2] G.M. Falco, A. Pelster, and R. Graham, Phys. Rev. A **75**, 063619 (2007)
[3] G.M. Falco, A. Pelster, and R. Graham, Phys. Rev. A **76**, 013624 (2007)
[4] P. Navez, A. Pelster, and R. Graham, App. Phys. B **86**, 395 (2007)

Q 44.3 Wed 15:15 P/H2

Hartree-Fock Theory of a Harmonically Trapped Dirty Bose-Einstein Condensate via the Replica Method — •Tama Khellil[1] and Axel Pelster[2] — [1]Department of Physics, Freie Universität Berlin, Germany — [2]Physics Department and Research Center OPTIMAS, Technische Universität Kaiserslautern, Germany

A recent non-perturbative approach towards the dirty boson problem relies on the Hartree-Fock theory which is worked out on the basis of the replica method [1]. Here we extend this approach for a weakly interacting Bose-gas at finite temperature in a quenched delta-correlated disorder potential from the homogeneous case to an anisotropic harmonic confinement within the Thomas-Fermi approximation. In this way we obtain and solve coupled self-consistency equations, which relies on a decomposition of the particle density into the condensate density, the thermal density as well as the density of fragmented local Bose-Einstein condensates within the respective minima of the random potential landscape. Although we reproduce for weak disorder and at zero temperature the seminal results of Huang and Meng from a Bogoliubov theory [2,3] only qualitatively, we yield for strong enough disorder a quantum phase transition to a Bose-glass phase [4].

[1] R. Graham and A. Pelster, I. J. Bif. Chaos **19**, 2745 (2009)
[2] K. Huang, H.-F. Meng, Phys. Rev. Lett. **69**, 644 (1992)
[3] G.M. Falco, A. Pelster, and R. Graham, Phys. Rev. A **75**, 063619 (2007)
[4] P. Navez, A. Pelster, and R. Graham, App. Phys. B **86**, 395 (2007)

Q 44.4 Wed 15:30 P/H2

The XYZ-chain with Dzyaloshinskii-Moriya interactions and interacting Majorana fermions with complex hopping — •Johannes Jünemann and Matteo Rizzi — Johannes Gutenberg-Universität Mainz, Institut für Physik, Staudingerweg 7, D-55099 Mainz, Germany

Advances in cold-atom experiments put the realization of more and more intriguing spin-Hamiltonians within reach. Here, we investigate the XYZ-model with Dzyaloshinskii-Moriya interactions which arises, e.g., from the strong-coupling limit in a two-species bosonic chain with spin-orbit coupling, complex hopping and anisotropic on-site interactions. Contrary to earlier work, which focussed on the regime with ferromagnetic interactions along the direction of the Dzyaloshinskii-Moriya vector, we lay out the full phase diagram, including the antiferromagnetic regime. We point out the duality to an enriched Kitaev-Majorana chain, where interactions and a magnetic field inducing a supercurrent are present in addition to the usual p-wave pairing. We therefore describe the phase diagram also in terms of topological properties of the dual fermionic model.

Q 44.5 Wed 15:45 P/H2

An ultracold ytterbium quantum gas in a state dependent lattice — •Moritz Höfer[1,2], Christian Hofrichter[1,2], Luis Riegger[1,2], Francesco Scazza[1,2], Diogo Rio Fernandes[1,2], Immanuel Bloch[1,2], and Simon Fölling[1,2] — [1]Ludwig-Maximilians-Universität, München, Deutschland — [2]Max-Planck-Institut für Quantenoptik, Garching, Deutschland

Ytterbium atoms feature peculiar properties compared to alkali atoms such as the existence of a metastable excited state as well as a strong decoupling between the nuclear and the electronic spin in the ground state.

These metastable states have been proposed for the study of many-body systems such as Kondo physics. An important ingredient for such simulations is the ability to create localized and mobile atoms in the same optical lattice due to the different AC polarizabilities of the relevant electronic states.

Here we report on our implementation of a state dependent lattice for the two electronic configurations of bosonic and fermionic ytterbium, which can be used for preparing specific Hamiltonians as well as for tuning the dynamics of the system.

Q 44.6 Wed 16:00 P/H2

Quantum simulation of curvature in finite size optical lattices with anharmonic traps — •Nikodem Szpak — Fakultät für Physik, Universität Duisburg-Essen

The usually undesirable effects of finite lattice sizes, due to the spatial limitations of the laser beams, can be mapped onto an effective curvature of a fictitious surface in which the ultracold atoms are hopping. Combined with specially designed anharmonic traps these systems, in their low energy limit, become quantum simulators for evolution of quantum fields in curved spaces. We present our latest results on this analogy and give some examples of artificially designed spaces with positive and negative curvature. We also show how methods of differential geometry can be used to deal with realistic inhomogeneous optical lattices.

Q 44.7 Wed 16:15 P/H2

Tunable anisotropic superfluidity in optical Kagome superlattice — •Xue-Feng Zhang[1], Tao Wang[1,2], Sebastian Eggert[1], and Axel Pelster[1] — [1]Physics Department and Research Center OPTIMAS, Technische Universität Kaiserslautern, Germany — [2]Department of Physics, Harbin Institute of Technology, China

We study the extended Bose-Hubbard model for the optical Kagome superlattice which is generated by enhancing the long wavelength laser in one direction. By combining Quantum Monte Carlo simulations with the Generalized Effective Potential Landau Theory [1,2], we find not only the Mott insulator-superfluid quantum phase transition, but also striped solid phases with non-integer filling factors. Furthermore, we determine with high accuracy the quantum phase diagram for different trap potential offsets. Due to the delicate interplay between on-site repulsion and artificial symmetry breaking, the superfluid density turns out to be anisotropic which reveals its tensorial property. Coun-

terintuitively, the bias of the anisotropy is alternating between x- and y-direction while tuning the particle number or the hopping strength. Finally, we discuss how to observe such phenomenon experimentally, in particular via time-of-flight absorption measurements.

[1] F.E.A. dos Santos and A. Pelster, Phys. Rev. A **79**, 013614 (2009)
[2] T. Wang, X.-F. Zhang, S. Eggert, and A. Pelster, Phys. Rev. A **87**, 063615 (2013)