TT 25: Quantum Liquids, Bose-Einstein Condensates, Ultracold Atoms, ...

Time: Thursday 14:00–15:45 Location: H18

TT 25.1 Thu 14:00 H18

From superfluidity to Anderson-localization in quasi 1d Bose-Einstein condensates. — •Tobias Paul, Patricio Leboeuf, and Nicolas Pavloff — Laboratoire de Physique Théorique et Modèles Statistiques, Universite Paris Sud, Batiment 100, F-91405 Orsay Cedex

The interplay between particle-particle interactions and disorder-induced interference effects is a challenging aspect of condensed matter physics, which is due to the advent of coherent atom manipulation nowadays revisited in guided Bose-Einstein condensates [1,2]. In this contribution we present a new, global analysis of the coherent condensate flow through a disordered region. We show that a variation of the condensate velocity v with respect to the disordered potential induces different regimes of quantum transport. We demonstrate the existence of three different regimes: At velocities v small compared to the sound velocity c the flow shows superfluid behaviour, whereas a domain of time dependent flow is reached when v becomes comparable to c. For velocities v considerably larger then the sound velocity again a stationary regime is found. In this domain, depending of the extent of the disordered region, the system enters an Anderson localized phase.

[1] D. Clement *et al.* Phys. Rev. Lett. **95**, 170409 (2005)
[2] T. Schulte *et al.* Phys. Rev. Lett. **95**, 170411 (2005)

TT 25.2 Thu 14:15 H18

Glassy behavior of Bose-Bose mixtures in one-dimensional optical lattices — •Tommaso Roscilde and Juan Ignacio Cirac — Max-Planck-Institut fuer Quantenoptik, Gaching b. Muenchen

We numerically investigate the properties of strongly repulsive two-boson mixtures in one-dimensional optical lattices, targeting their ground state either by slow cooling from high temperature, or by a slow change in the Hamiltonian parameters starting from the weakly interacting regime. The two bosonic species have very different effective masses, so that the slow bosons can act as an effective potential to the faster ones. When the interspecies repulsion is strong compared with the intraspecies one, a phase-separated ground state is masked by an exponentially large number of metastable *quantum emulsion* states, in which the two species are fragmented into microscopic droplets. The quantum emulsion states can be regarded as the out-of-equilibrium realization of a localization phenomenon, in which each species acts as a random potential to the other one, effectively localizing it. Quantum Monte Carlo investigations reveal an extremely slow relaxation of the system towards equilibrium, typical of a glassy phase. Increasing the intraspecies repulsion for the fast bosons drives them through a quantum phase transition to the superfluid state.

TT 25.3 Thu 14:30 H18

Dynamical mean-field theory for the Bose-Hubbard model — •Krzysztof Byczuk and Dieter Vollhardt — Theoretical Physics III, Center for Electronic Correlations and Magnetism, Institute for Physics, University of Augsburg, D-86135 Augsburg, Germany

The Bose-Hubbard model and Bose-Einstein condensation are investigated on an infinite dimensional lattice. A new way of rescaling the hopping amplitudes is introduced. This leads to a comprehensive theory which is exactly solvable in the limit of infinite dimensions. The solution is given by dynamical mean-field type equations for normal bosons plus an integro-differential Gross-Pitaevski type equation for superfluid bosons coupled to the normal component by dynamical hybridization functions. Local temporal correlations in the normal and superfluid components are treated exactly whereas spatial correlations are absent. All known limiting cases (free gas, atomic limit, Bogoliubov, Bogoliubov-Hartree, and Popov theories) are recovered. Possible strategies to solve this dynamical mean-field theory for correlated bosons are discussed.

TT 25.4 Thu 14:45 H18

Supersolids in confined fermions on one-dimensional optical lattices — •Farshid Karim Pour[1], Marcos Rigol[2], Stefan Wessel[1], and Alejandro Muramatsu[1] — [1]Institut für Theoretische Physik III, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [2]Department of Physics and Astronomy, University of Southern California Los Angeles, CA 90089, USA

Using quantum Monte Carlo simulations, we show that density-density and pairing correlation functions of the one-dimensional attractive fermionic Hubbard model in a harmonic potential can be characterized by the anomalous dimension K_ρ of a corresponding periodic system. This allows to determine the conditions for a supersolid in a harmonic trap. We show explicitely, that under these conditions the structure form factors for both correlation functions scale with the same exponent as the system size increases, giving rise to a (quasi-) supersolid.

TT 25.5 Thu 15:00 H18

Superfluidity in small 2D trapped systems of charged bosons — •Jens Böning, Alexei Filinov, and Michael Bonitz — Christian-Albrechts Universität Kiel, Institut für Theoretische Physik und Astrophysik, Leibnizstraße 15, 24098 Kiel, Germany

Superfluidity in a trapped cloud of quantum particles is defined using the cloud's response to a rotation of the external potential. The effect is known as the Hess-Fairbank or non classical moment of inertia (NCRI) effect and corresponds to the Meissner effect for superconductivity. It originates from the impossibility to excite vortices in macroscopic systems with an accoustic phonon like energy spectrum and is, thus, inseperably connected to inter-particle interactions. However, due to the discrete nature of the spectrum in trapped finite systems, the NCRI effect can be observed in quantum systems in any case regardless of the presense of interactions. We investigate small bosonic systems in order to distinguish between effects related to a finite system size, inter-particle interactions and quantum statistics. Our results are obtained with first principle path-integral Monte-Carlo (PIMC) simulations [1] and are compared to analytical expressions for the ideal case based on permutations cycles [2], respectively.

[1] Michael Bonitz and Dirk Semkat (eds.): *Introduction to Computational Methods in Many Body Physics*, Rinton Press Inc., 2006
[2] J. Schneider and H. Wallis: *Fully quantum mechanical moment of inertia of a mesoscopic Bose gas* Eur. Phys. J. B **18**, 507–512, 2000

TT 25.6 Thu 15:15 H18

Correlation effects and superfluidity in mass-asymmetric electron-hole bilayers — •Alexei Filinov[1,2], Patrick Ludwig[1], Jens Böning[1], Yurii Lozovik[2], and Michael Bonitz[1] — [1]Institute für Theoretische Physik und Astrophysik, Leibnizstrasse 15, 24098 Kiel — [2]Institute of Spectroscopy RAS, Troitsk, 142190, Russia

We present an overview on path integral Monte Carlo (PIMC) studies of spatially separated electron-hole bilayers [1]. As was recently observed for bulk semiconductors [2], holes undergo a phase transition to a crystalline state if the mass ratio exceeds $M_{cr} \approx 80$. Here, we extend this analysis to bilayers where M_{cr} depends on d and the in-layer particle density. We consider the low density regime when the spin statistics has a negligible effect on the localized states of the holes. With the decrease of d the crystal melts via the formation of indirect excitons. We also find a crystalline state of excitons at lower temperatures. By considering the excitons as a composite bosons we performed PIMC simulations including the exchange effects. The detailed analysis of dependence of the superfluid fraction in mesoscopic systems (two coupled quantum dots) and macroscopic systems are presented. The role of the finite size effects on the condensate fraction and the critical temperature, and deviation from the macroscopic limit, is discussed.

[1] A.Filinov, P.Ludwig, Yu.E.Lozovik, M.Bonitz and H.Stolz, J. Phys: Conf. Series **35**, 197 (2006); Contrib. Plasma Phys., accepted (2007). [2] M.Bonitz, V.S.Filinov, V.E.Fortov. P.R.Levashov, and H.Fehske, J. Phys. A: Math. Gen. **39**, 4717 (2006).

TT 25.7 Thu 15:30 H18

Coherent Matter Waves Emerging from Mott-Insulators — Karen Rodriguez[1], •Salvatore Manmana[1,2,3], Marcos Rigol[4], Reinhard Noack[2], and Alejandro Muramatsu[1] — [1]Institut für Theoretische Physik III, Universität Stuttgart, Pfaffenwaldring 57, D-70550 Stuttgart — [2]AG Vielteilchennumerik, Fachbereich Physik, Philipps-Universität Marburg, D-35032 Marburg — [3]Institute of Theoretical Physics, EPFL, CH-1015 Lausanne (Switzerland) — [4]Physics Department, University of California, Davis, CA 95616 (USA)

Using the adaptive time-dependent density matrix renormalization group method (adaptive t-DMRG), we investigate the non-equilibrium dynamics of a system of strongly interacting soft-core bosons on a one-dimensional lattice modelled by the bosonic Hubbard model. We study the formation of (quasi-)coherent matter waves emerging from an initial Mott insulator state. It has been shown previously that a quasi-condensate emerges at momentum $k_{\text{cond}} = \pi/2a$, where a is the lattice constant, in the limit of infinitely strong repulsion (hard-core bosons). Here we show that this phenomenon persists for all values of the repulsive interaction that lead to a Mott insulator at a commensurate filling. Different methods for tuning the wave vector of the emerging matter wave are discussed.