TT 38: Matter At Low Temperature: Quantum Liquids, Bose-Einstein Condensates, Ultra-cold Atoms, ...

Time: Friday 10:15–13:00 Location: H 3010

TT 38.1 Fri 10:15 H 3010

Supersolid Bose-Fermi Mixtures in Optical lattices — •Irakli Titvinidze, Michiel Snoek, and Walter Hofstetter — Institut für Theoretische Physik, J. W. Goethe-Universität, D-60438 Frankfurt, Germany

We study a mixture of strongly interacting bosons and fermions with on-site repulsion in a three-dimensional optical lattice. We apply a generalized DMFT (gDMFT) scheme, which is exact in infinite dimensions and reliably describes the full range from weak to strong coupling. In first instance we restrict ourselves to the case of a mixture of bosons and spinless fermions at half filling. In this case a supersolid forms for weak Bose-Fermi repulsion, in which bosonic superfluidity coexists with charge-density wave order. For stronger interspecies repulsion the bosons become localized while the charge density wave order persists. The system is unstable against phase separation for weak repulsion among the bosons. Extending this to the case of spinfull fermions, we also find an antiferromagnetic phase.

[1] I. Titvinidze, M. Snoek, and W. Hofstetter; preprint: arXiv:0708.3241

TT 38.2 Fri 10:30 H 3010

Noise correlation for fermions with attractive interactions confined in one-dimensional optical lattices — •Farshid Karim Pour[1], Stefan Wessel[1], Marcos Rigol[2], and Alejandro Muramatsu[1] — [1]Institut für Theoretische Physik III, Universität Stuttgart, Pfaffenwaldring 57, D-70550 Stuttgart, Germany. — [2]Department of Physics, University of California, Santa Cruz, 1156 High Street Santa Cruz, CA 95064, USA

Using quantum Monte Carlo simulations, we study the behavior of the one-dimensional attractive fermionic Hubbard model in different confinement potentials. Studying the noise correlation function we show that the signals for charge-density wave and superconductivity can clearly be seen in the noise correlation function for such fermionic systems. We show that density-density and pairing correlation functions are characterized by the anomalous dimension K_ρ of a corresponding periodic system. This allows us to determine conditions for a supersolid state inside a trap. We find that, eventhough the SU(2) symmetry is broken by the confining potential, density-desity and pairing correlations can decay with exactly the same exponent, hence giving rise to a (quasi-)supersolid in 1D[1].

[1] F. Karim Pour, M. Rigol, S. Wessel, A. Muramatsu, PRB **75**, 161104(R) (2007)

TT 38.3 Fri 10:45 H 3010

FFLO states in a one-dimensional lattice with polarized, trapped fermions and attractive interactions — •Fabian Heidrich-Meisner[1] and Adrian Feiguin[2] — [1]Institut für Theoretische Physik C, RWTH Aachen, 52064 Aachen, Germany — [2]Microsoft Station Q, University of California, Santa Barbara, CA 93106, USA

We study the properties of a one-dimensional (1D) gas of fermions focusing on the case of unequal spin populations and strong attractive interaction. While the emergence of Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) states has previously been predicted from mean-field and local density approximation studies, here [1], we address this problem by means of a quasi-exact numerical method, the density matrix renormalization group technique. In the low density regime, the system phase-separates into a well defined superconducting core and a fully polarized metallic cloud surrounding it. We argue that the superconducting phase corresponds to a 1D analogue of the FFLO state, with a finite center-of-mass momentum that scales linearly with the magnetization. Moreover, we find that the spatial decay of pair correlations follows a power law. In the large density limit, the system allows for four phases: in the core, we either find a Fock state of localized pairs or a metallic shell with spin-down fermions moving in a fully filled background of spin-up fermions. As the magnetization increases, the Fock state disappears to give room for a metallic phase, with a partially polarized superconducting FFLO shell and a fully polarized metallic cloud surrounding the core.

[1] A.E. Feiguin, F. Heidrich-Meisner, arXiv:0707.4172.

TT 38.4 Fri 11:00 H 3010

Spin - charge separation in ultracold two-component Bose-gases — •Adrian Kleine[1], Corinna Kollath[2], Ian P. McCulloch[3], Thierry Giamarchi[2], and Ulrich Schollwöck[1] — [1]Institut für Theoretische Physik C, RWTH Aachen, D-52056 Aachen, Germany — [2]DPMC-MaNEP, University of Geneva, CH-1211 Geneva, Switzerland — [3]School of Physical Sciences, University of Queensland, Brisbane, Qld 4072, Australia

The experimental search for signatures of spin-charge separation, a hallmark feature of one-dimensional interacting electron systems, is a key topic in strongly correlated electron physics. The recent progress in ultracold atom realizations allows for both interaction parameters to be fine-tuned and to trap atoms in quasi one dimensional set-ups, hence opening a novel path towards the observation of spin charge separation. Here we theoretically study a two-component system of bosonic ultracold atoms in the framework of the Bose-Hubbard model. We show that even close to a competing phase separation regime, such a model features spin charge separation [1]. To this end, we determine the real-time evolution of a single particle excitation and the single-particle spectral function using density-matrix renormalization group techniques. In anticipation of experimental realizations we calculate the velocities for spin and charge perturbations for a wide range of parameters.

[1] A. Kleine et al. to appear in Phys. Rev. A, preprint arXiv:0706.0709

TT 38.5 Fri 11:15 H 3010

Trionic phase of the attractive SU(3)-Hubbard model — •Guido Klingschat and Carsten Honerkamp — Theoretische Physik, Universität Würzburg

Recently, a quantum phase transition from a color superfluid to a colorless phase with conglomerates of 3 fermions on a single site ('trions') has been proposed to occur in the attractive SU(3)-Hubbard model [Rapp et al., Phys. Rev. Lett. 98, 160405 (2007)]. Here we analyze the properties of the trionic phase using exact diagonalization. We determine the spectral function of single particle and trionic excitations, and compute spatial correlations. This way we can characterize the effective quasiparticles of the strong coupling phase.

15 min. break

TT 38.6 Fri 11:45 H 3010

Circulating currents in fermionic bilayers — •Alexei Kolezhuk — Institut für Theoretische Physik C, RWTH Aachen, Germany

It is shown that fermionic polar molecules or atoms in a bilayer optical lattice can undergo the transition to a state with circulating currents, which spontaneously breaks the time reversal symmetry. The bilayer lattice design is proposed, estimates of relevant temperature scales are given and experimental signatures of the circulating current phase are identified. Related phenomena in bosonic and spin systems with ring exchange are discussed.

TT 38.7 Fri 12:00 H 3010

Vorticity in rotating 2D Bose-Einstein condensates in the regime of strong coupling — •Tanja Rindler-Daller — Institut für Theoretische Physik, Universität zu Köln, Zülpicher Strasse 77, 50937 Köln, Germany

When Bose-Einstein condensates are subjected to an external rotation different vortex structures appear depending on the applied angular velocity Ω. We study the ground state within the Gross-Pitaevskii theory in the limit of large coupling constant for condensates which are confined in (asymptotically) homogeneous trap potentials [1,2]. We identify three regimes in Ω, which are characterized by a distinctive behaviour in the density profile and vortex structures, by rigorous estimates.

[1] M.Correggi, T.Rindler-Daller, J.Yngvason, J.Math.Phys. 48, 042104 & 102103 (2007)

[2] T.Rindler-Daller, accepted by Physica A

TT 38.8 Fri 12:15 H 3010

Shuttle for cold atoms: atomic quantum dot inside Bose

Josephson junction. — •Anna Posazhennikova[1], Uwe R. Fischer[2], and Christian Iniotakis[3] — [1]Physikalisches Institut, Universitaet Bonn, Germany — [2]Institut fuer Theoretische Physik, Eberhard-Karls-Universitate Tuebingen, Germany — [3]ETH Zuerich, Institut fuer Theoretische Physik, Zuerich, Switzerland

We study an atomic quantum dot representing a single hyperfine "impurity" atom which is coherently coupled to two well-separated Bose-Einstein condensates. It is demonstrated that the quantum dot by itself can induce coherent oscillations of the particle imbalance between the condensates even when the conventional tunneling between the two condensates is exponentially small and can be completely neglected. In the limit of noninteracting condensates, we provide an analytical solution to the coupled nonlinear equations of motion which is in agreement with the full numerical treatment.

TT 38.9 Fri 12:30 H 3010

Condensate formation in Bose-gas upon cooling — •Roman Saptsov[1], Efim Brener[1], and Sergey Iordanskiy[2] — [1]IFF, FZ-Jülich, Jülich, Germany — [2]Landau Istitute for Theoretical Physics, Moscow, Russia

The mechanism for the transition of a Bose gas to the superfluid state via thermal fluctuations is considered. It is shown that in the process of external cooling some critical fluctuations (instantons) are formed above the critical temperature. The probability of the instanton formation is calculated. It is found that this probability increases as the system approaches the transition temperature.

TT 38.10 Fri 12:45 H 3010

Construction of an optical dipole trap for studying bosonic mixtures — •Lars Steffens[1,2], Shincy John[1], Claudia Weber[1], Artur Widera[1], Manfred Fiebig[2], and Dieter Meschede[1] — [1]IAP, Universität Bonn, Wegelerstr. 8, 53115 Bonn, Germany — [2]HISKP, Universität Bonn, Nussallee 14-16, 53115 Bonn, Germany

Because of their well controlable behaviour, ultracold atomic gases are a useful tool for studying quantum mechanical many body systems. A variety of problems of solid state physics could be modelled by using systems of ultracold gases. In addition, studying *mixtures* of ultracold gases lead to an improved understanding of quantum mechanical multi component systems. Up to now, mostly boson-fermion mixtures were considered while only little research has been done on boson-boson mixtures of different atomic species. Here the construction of an simple optical dipole trap designed for Feshbach spectroscopy of Rb-Cs mixtures is presented. The response of the atomic species to the light field is discussed. A precise simulation of the optical potential by a 3D-simulation of the light field including aberration and diffraction effects is given. These results can be used as a basis for the construction of other dipole potential setups that can be used to describe a broad variety of external parameters.