TT 16 Solids At Low Temperature: Quantum Liquids, Bose-Einstein Condensates, Ultra-cold Atoms, ...

Time: Tuesday 09:30–11:30 Room: HSZ 105

TT 16.1 Tue 09:30 HSZ 105

Slave-boson approach for Bose-Einstein condensate in optical lattices — •Christopher Moseley and Klaus Ziegler — Institut für Physik, Universität Augsburg, 86135 Augsburg

A strongly interacting Bose-Einstein condensate in an optical lattice is treated by applying a slave-boson approach to hard-core bosons. A mean-field calculation for the condensate wave function leads to a renormalized Gross-Pitaevskii theory that describes both the dilute regime (like the conventional Gross-Pitaevskii equation) and the dense regime. Finite temperature effects as well as the phase transition to the Mott insulating state are found within this approach. Moreover, we calculate the quasiparticle excitation spectrum that in the dilute regime agrees with Bogoliubov theory.

TT 16.2 Tue 09:45 HSZ 105

Supersolid Bosons on the Triangular Lattice — •Stefan Wessel[1] and Matthias Troyer[2] — [1]Institut für Theoretische Physik III, Universität Stuttgart, 70550 Stuttgart, Germany — [2]Theoretische Physik, ETH Zürich, CH-8093 Zürich, Switzerland

The zero temperature phase diagram of hardcore bosons on the triangular lattice with nearest neighbor repulsion is determined using quantum Monte Carlo simulations. The system exhibits an extended supersolid phase emerging from an order-by-disorder effect as a novel way of a quantum system to avoid classical frustration. We analyze the nature of the supersolid phase and its stability in competition with phase-separation, which we find to occurs in other regions of parameter space.

TT 16.3 Tue 10:00 HSZ 105

Josephson tunneling between two Bose-Einstein condensates, coupled via an atmoic quantum dot. — •Ingrid Bausmerth[1], Uwe R. Fischer[2], and Anna Posazhennikova[1] — [1]Institut für Theoretische Festkörperphysik, Universität Karlsruhe, Wolfgang-Gaede-Str. 1, 76128 Karlsruhe — [2]Institut für Theoretische Physik, Eberhard-Karls-Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen

We study the Josephson tunneling effect in the system of weakly coupled BECs. This setup is known to exhibit a novel quantum phenomenon - macroscopic self-trapping (MST). We consider the way MST is affected by an atomic quantum dot embedded between the two condensates.

TT 16.4 Tue 10:15 HSZ 105

Temperature in One-Dimensional Bosonic Mott Insulators — •Kai P. Schmidt[1], Alexander Reischl[2], and Götz S. Uhrig[3] — [1]Institute of Theoretical Physics, École Polytechnique Fédérale de Lausanne, CH 1015 Lausanne, Switzerland — [2]Institut für Theoretische Physik, Universität zu Köln, Zülpicher Straße 77, 50937 Köln, Germany — [3]Theoretische Physik, Geb. 38, FR 7.1, Universität des Saarlandes, D-66123 Saarbrücken, Germany

The Mott insulating phase of a one-dimensional bosonic gas trapped in optical lattices is described by a Bose-Hubbard model. A continuous unitary transformation is used to map this model onto an effective model conserving the number of elementary excitations. We obtain quantitative results for the kinetics and for the spectral properties of the low-energy excitations for a broad range of parameters in the insulating phase. By these results, recent Bragg spectroscopy experiments are explained. Evidence for a significant temperature of the order of the microscopic energy scales is found. The temperature scale deduced from the spectroscopy is embedded in a consistent picture of the thermodynamic properties of bosons in the Mott insulating phase when loaded adiabatically into one-dimensional optical lattices. We find a crucial dependence of the temperature in the optical lattice on the doping level of the Mott insulator. In the undoped case, the temperature is of the order of the large onsite Hubbard interaction. In contrast, at a finite doping level the temperature jumps almost immediately to the order of the small hopping parameter.

TT 16.5 Tue 10:30 HSZ 105

Generation of coherent matter waves from correlated insulators — •Karen Rodriguez[1], Salvatore Manmana[1,2], Marcos Rigol[3], Reinhard Noack[2], and Alejandro Muramatsu[1] — [1]Institut für Theoretische Physik III, Universität Stuttgart, Pfaffenwaldring 57 / V, 70550 Stuttgart — [2]AG Vielteilchennumerik, Fachbereich Physik, Philipps-Universität Marburg, D-35032 Marburg, Germany — [3]Physics Department, University of California, Davis, CA 95616, USA

We study the evolution of matter waves resulting from the free expansion of an initially confined Mott-insulator, using a variant of the time-dependent density matrix renormalization group method (DMRG) that approximates the time-evolution operator within a Krylov subspace. A carefull comparison with the exact solution in the case of hard-core bosons [1] is performed, in order to determine the limitations of the algorithm. Finally, we discuss the expansion of soft-core bosons.

[1] M. Rigol and A. Muramatsu, Phys. Rev. Lett. **93**, 230404 (2004); *ibid.* **94**, 240403 (2005).

TT 16.6 Tue 10:45 HSZ 105

About the dependence of distribution for the superfluid density of He^4 absorbed in a narrow single walled carbon nanotube in the vicinity of the λ-transition. — •Vilchynskyi Stanislav and Tkachenko Olena — Kiev Taras Shevchenko National University

We report the results of an iteration calculations of the temperature dependence of λ-transition and distribution for the superfluid density of He^4 absorbed in a narrow single walled carbon nanotube in the vicinity of λ-transition. The calculations were made for different values of the carbon nanotube diameter and a value of an inoculating interaction V_0 (the depth of a potential well). We demonstrate the decrease of the temperature of the λ -transition and superfluid density in He^4 absorbed in the nanotube and find an appropriate "temperature shift". It was shown that that if the nanotube's diameter is invariable, the increment of the interaction between a superfluid helium and carbon atoms will reduce to the decreasing of superfluid density (but to the increasing of the "temperature shift"). In this case the appearance of of superfluid component decelerates.

TT 16.7 Tue 11:00 HSZ 105

Thermodynamics of strongly anisotropic roton system in superfluid ^{4}He — •Valeriy Slipko[1], Igor Adamenko[1], Konstantin Nemchenko[1], and Adrian Wyatt[2] — [1]Karazin Kharkov National University, Svobody Sq. 4, Kharkov 61077, Ukraine — [2]School of Physics, University of Exeter, Exeter EX4 4QL, United Kingdom

Recently strongly anisotropic quasiparticle systems have been created in liquid ^{4}He [1, 2]. The strong anisotropy means that the drift velocity can be close to the Landau critical velocity. By using the phonon-roton model, we have obtained analytical expressions for all thermodynamical functions up to the Landau critical velocity. It turns out that for strongly anisotropic quasiparticle systems of superfluid ^{4}He, the temperature at which the contributions of phonons and rotons are comparable, decreases with increasing drift velocity. This creates a rather unusual situation; rotons can dominate in the whole temperature range. This is in contrast to isotropic quasiparticle systems, where the roton contribution to the thermodynamical functions, is negligible for temperatures less than 0.5 K. The reason for this unusual behavior of the roton thermodynamics is that, for velocities close to critical value, we cannot consider rotons as a classical gas which obeys Boltzmann statistics. Instead it must be considered by Bose statistics. The effective roton energy gap decreases when the drift velocity increases. This results in a large roton number density compared to the phonon number density, even at very low temperatures.

[1] Vovk R.V., Williams D.H. and Wyatt A.F.G. Phys. Rev. B68, 134508 (2003).

[2] Wyatt A.F.G. and Brown M. Physica B, 165&166, (1990).

TT 16.8 Tue 11:15 HSZ 105

Bilayer helium-3: a new two dimensional heavy fermion system with quantum criticality — •Michael Neumann, Jan Nyéki, Brian Cowan, and John Saunders — Dept. of Physics, Royal Holloway, Univ. of London, United Kingdom

Previous work [1] has shown how monolayer ^{3}He adsorbed on graphite behaves as a two dimensional Mott-Hubbard system, complete with a "metal-insulator" transition. We report new results on bilayer ^{3}He, which behaves as a two-dimensional two-band heavy fermion fluid. Evidence for this behaviour derives from extensive heat capacity and magnetisation measurements of ^{3}He adsorbed on graphite pre-plated by a solid bilayer of ^{4}He. The first ^{3}He layer adsorbed on this composite substrate remains fluid up to and beyond layer promotion. However, it is observed to solidify significantly before the second ^{3}He layer is completed. Remarkably, at fluid coverages on the verge of solidification, we observe a distinctive heat capacity and magnetisation maximum, which occurs at progressively lower temperatures as the coverage is increased. The magnetic instabilities in the fluid and the close analogies with quantum critical heavy fermion systems will be discussed in detail.

[1] Evidence for a Mott-Hubbard Transition in a Two-Dimensional ^{3}He Fluid Monolayer, A. Casey, H. Patel, J. Nyéki, B. P. Cowan, and J. Saunders. Phys. Rev. Lett. 90, 115301 (2003)