

TT 9 Solids at Low Temperature - Quantum Liquids, Bose-Einstein Condensates, Ultracold Atoms, ...

Zeit: Freitag 17:00–18:45

Raum: TU H3027

Hauptvortrag

TT 9.1 Fr 17:00 TU H3027

Ultracold Atoms in Optical Lattices: Tunable Quantum Many-Body Systems — ●WALTER HOFSTETTER — Theoretische Physik A, RWTH Aachen, Templergraben 55, 52056 Aachen

Cold atoms in optical lattices offer an exciting new laboratory where quantum many-body phenomena can be realized which are out of reach in solids. They can even serve as quantum simulators for notoriously difficult problems like high-temperature superconductivity. In this talk I will focus on recent developments and new results in multi-component systems: Fermionic atoms with SU(N) symmetry have exotic superfluid and flavor-ordered ground states. I will discuss symmetry breaking, collective modes and detection issues, e.g. in Bragg scattering. On the other hand, bosonic multi-flavor ensembles allow for engineering of quantum spin hamiltonians which are interesting from a quantum computation point of view. I will also discuss effects of reduced dimensionality, in particular polaronic Luttinger liquids in 1d Fermi-Bose systems.

TT 9.2 Fr 17:30 TU H3027

1/N-Expansion for Interacting Bose Gas — ●FLAVIO NOGUEIRA¹ and AXEL PELSTER² — ¹Institut für Theoretische Physik, Freie Universität Berlin, Berlin, Germany — ²Fachbereich Physik, Universität Duisburg-Essen, Essen, Germany

We study the interacting Bose gas by treating a field-theoretic model with N complex fields via a $1/N$ expansion. The resulting excitation spectrum follows from solving a self-consistent equation which contains a temperature-dependent effective interaction. Thermal fluctuations generate an anomalous scaling behavior in the excitation spectrum which leads to a second-order phase transition. Finally, we determine within our $1/N$ approach the temperature dependence of both the condensate density and the superfluid density.

TT 9.3 Fr 17:45 TU H3027

Quantum Monte Carlo simulations of fermions with attractive interactions confined on optical lattices — ●F. KARIM POUR¹, F. DE LEÓN¹, M. RIGOL^{1,2}, and A. MURAMATSU¹ — ¹Institut für Theoretische Physik III, Universität Stuttgart, 70550 Stuttgart, Germany — ²Physics Department, University of California, Davis, CA 95616, USA

We present numerical simulations for the negative U Hubbard model for fermions confined on one- (1D) and two-dimensional (2D) lattices. In the 1D case we calculate the exponents related to diagonal and off-diagonal quasi-long range order for different trapping potentials and compare them with the corresponding ones in periodic system. In 2D we characterize the crossover region between the BCS and BEC regimes. Finally, we discuss the possibility of coexistence of diagonal and off-diagonal long range order in the presence of a trapping potential.

TT 9.4 Fr 18:00 TU H3027

Non-equilibrium dynamics of hard-core bosons on 1D lattices: short vs large time results. — ●M. RIGOL^{1,2} and A. MURAMATSU² — ¹Physics Department, University of California, Davis, CA 95616, USA — ²Institut für Theoretische Physik III, Universität Stuttgart, 70550 Stuttgart, Germany

Based on an exact treatment we study the non-equilibrium dynamics of hard-core bosons on one-dimensional lattices. Starting from a pure Fock state we find that quasi-long range correlations develop very fast in the system, and they lead to the emergence of quasi-condensates at finite momentum [1]. The exponent observed in the power-law decay of the one-particle density matrix, which develops dynamically, is the same that has been proven to be universal in the equilibrium case [2]. We also study the time evolution of clouds of hard-core bosons when they are released from a harmonic trap. In this case we show that the momentum distribution of the free expanding hard-core bosons approaches to the one of noninteracting fermions, in contrast to the known behavior in equilibrium systems [3].

[1] M. Rigol and A. Muramatsu, cond-mat/0403387, to appear in Phys. Rev. Lett. (2004)

[2] M. Rigol and A. Muramatsu, Phys. Rev. A **70**, 031603(R) (2004); ibid. cond-mat/0409132.

[3] M. Rigol and A. Muramatsu, cond-mat/0410683

TT 9.5 Fr 18:15 TU H3027

New superfluidity theory: a weakly interacting but non-dilute Bose gas — ●JEAN-BERNARD BRU¹ and STEFAN ADAMS² — ¹FB Mathematik und Informatik, Johannes Gutenberg-Universität, D-55099 Mainz — ²Max-Planck-Institut für Mathematik in den Naturwissenschaften Inselstraße 22, D-04103 Leipzig

The first microscopic theory of superfluidity was originally found in 1947 by Bogoliubov in three revolutionary papers on the theory of interacting Bose gas. His Weakly Imperfect Bose Gas (WIBG) coming from the truncation of a full interacting Bose gas was a starting point for this theory. However, only very few rigorous results concerning his WIBG and ansatz were previously done until 1998-2000 where a first rigorous analysis of this Bogoliubov model (WIBG) was found at all temperatures and densities. The aim of this talk is to do a more deep analysis of the Bogoliubov theory, including all recent studies (2001) and some new criticizes (2002-2004). Actually, this more detailed analysis gives rise to a new microscopic theory of superfluidity at all temperatures (2004) then introduced at the end of this talk.

In particular, the talk should be concluded by the corresponding phase diagram of this new theory: it exhibits the "Landau-type" excitation spectrum in the presence of a depleted Bose condensation for small temperatures with the formation of "Cooper-type pairs", even at zero-temperature (experimentally, an estimate of the fraction of condensate in liquid ⁴He at T=0 K is 9 %).

TT 9.6 Fr 18:30 TU H3027

Magnetoelastic Coupling in the Spin Dimer System TlCuCl₃ — ●N. JOHANNSEN¹, T. LORENZ¹, A. VASILEV², A. OOSAWA³, and H. TANAKA⁴ — ¹II. Physikalisches Institut, Universität zu Köln, Zùlpicher Str. 77, 50937 Köln — ²Departement of Low-Temperature Physics, Moscow State University, Moscow 119899, Russia — ³Advanced Science Research Center, Japan Atomic Energy Research Institute, Tokai, Ibaraki 319-1195, Japan — ⁴Departement of Physics Tokyo Institute of Technology, Oh-okayama, Meguro-ku, Tokyo 152-8551, Japan

We present high-resolution measurements of the thermal expansion and the magnetostriction on a single crystal of TlCuCl₃ which shows a field-induced magnetic order. In this material Cu²⁺ ions form S=1/2 spin dimers with an antiferromagnetic coupling. The spin gap between the singlet ground state and the first excited triplet state amounts only to about 0.65 meV. Therefore, a moderate magnetic field $H > 6$ T induces antiferromagnetic order with a staggered magnetization perpendicular to the applied field. The phase transition causes pronounced anomalies of opposite signs in the field and temperature dependencies of different lattice directions signaling a large magnetoelastic coupling. These anomalies allow for a precise determination of the phase boundaries, which turns out to be extremely sensitive to pressure, e.g. the transition field may change up to ± 200 %/GPa depending on the direction of uniaxial pressure. This drastic effect can be unambiguously traced back to changes of the intradimer coupling under pressure, whereas the interdimer couplings remain essentially unchanged. On the other hand, a replacement of the Tl by smaller K ions causes a strong change in the interdimer couplings.