# TT 15: MLT: Quantum Liquids, Bose-Einstein Condensates, Ultra-cold Atoms, ... 1

Time: Tuesday 14:00–16:15 Location: H18

TT 15.1 Tue 14:00 H18

**Transport and scale invariance in the unitary Fermi gas** — •Tilman Enss and Wilhelm Zwerger — Technische Universität München, Germany

The string theory conjecture of a universal lower bound on the shear viscosity to entropy ratio, characterizing a perfect fluid, has stimulated work from nuclear physics to ultracold atoms. We compute the bulk and shear viscosities of a strongly interacting Fermi gas in three dimensions above the superfluid transition temperature using a diagrammatic technique. It is shown that vertex corrections and the associated Aslamazov-Larkin contributions are crucial to reproduce the correct high-temperature limit and the vanishing of the bulk viscosity due to scale invariance. The resulting shear viscosity to entropy ratio has a minimum value above the superfluid transition that is a factor of five above the string theory bound. The results are compared to recent experimental data on the damping of collective modes of a trapped unitary Fermi gas.

TT 15.2 Tue 14:15 H18

**Ward identities and skeleton equations in the functional renormalization group approach to the BCS-BEC crossover** — •Lorenz Bartosch[1], Peter Kopietz[1], and Alvaro Ferraz[2] — [1]Institut für Theoretische Physik, Universität Frankfurt, Germany — [2]International Center for Condensed Matter Physics, Universidade de Brasília, Brazil

We use the functional renormalization group approach with partial bosonization in the particle-particle channel to study the effect of order parameter fluctuations on the BCS-BEC crossover of superfluid fermions in three dimensions. Our approach is based on a new truncation of the vertex expansion where the renormalization group flow of bosonic two-point functions is closed by means of skeleton equations (Dyson-Schwinger equations) and the superfluid order parameter is related to the single particle gap via a Ward identity. We explicitly calculate the chemical potential, the single-particle gap, and the superfluid order parameter at the unitary point and compare our results with experiments and previous calculations.

TT 15.3 Tue 14:30 H18

**Elastic anomalies at the field-induced quantum-critical point in the quasi 2D-antiferromagnet $Cs_2CuCl_4$** — •P. T. Cong, B. Wolf, S. Belz, N. Krüger, F. Ritter, W. Assmus, and M. Lang — Physikalisches Institut, Goethe- Universität, SFB/TR 49, D-60438 Frankfurt(M).

The quasi-2D antiferromagnet $Cs_2CuCl_4$ is one of the prime examples where the phenomenon of Bose-Einstein condensation (BEC) of magnetic excitations has been discussed [1]. The long-range antiferromagnetic order can be suppressed to $T_N = 0$ in a magnetic field $B_c \sim 8.5$ T (B//a), which constitutes a quantum critical point (QCP). At $B_c$, quantum-critical fluctuations are expected to give rise to anomalous physical properties at finite temperatures. Here we present a detailed investigation of the elastic constants and ultrasonic attenuation near the B-induced QCP. Distinct anomalies were found at $B_c \sim 8.5$ T, which are particularly strongly pronounced in the ultrasonic attenuation. Around $B_c$ below 0.2 K the ultrasonic attenuation of the $c_11$ mode exhibits a pronounced double structure, reminiscent of two anomalies of different origin. One is very sharp, strongly temperature dependent and is located at $T_N(B)$ and the other one is distinctly broader at slightly higher fields. [1] T. Radu *et al.*,PRL 95, 127202, (2005)

**Invited Talk** TT 15.4 Tue 14:45 H18

**Superconductivity vs. Superinsulation in TiN Thin Films** — •Christoph Strunk — Universität Regensburg, D-93040 Regensburg, Germany

TiN thin films display a very sharp superconductor-insulator transition both vs. degree of disorder and vs. magnetic field. In the insulating phase an abrupt drop of the already low, thermally activated conductance is observed below certain threshold voltages $V_{th}$, which has been interpreted as the transition to a novel 'superinsulating' state at very low temperatures [1]. Subsequently, similar experiments on $InO_x$ have been interpreted in terms of electron heating of an insulator with a strongly temperature-dependent conductance [2]. The experiments on the insulating side of the transition are complemented by a study of the IV-characteristics on the superconducting side, which demonstrates a striking duality between the transport characteristics on both sides of the transition. Our results are discussed in the light of recent experimental and theoretical developments.

[1] V. Vinokur *et al.*, Nature **452**, 613 (2008).
[2] M. Ovadia, B. Sacepe and D. Shahar, PRL **102**, 176802 (2009).

TT 15.5 Tue 15:15 H18

**Bogoliubov excitations in correlated disorder potentials** — •Christopher Gaul and Cord A. Müller — Physikalisches Institut, Universität Bayreuth, Deutschland

Bogoliubov excitations carry precious information about the properties of disordered Bose-Einstein condensates. By a saddle-point expansion of the Gross-Pitaevskii energy functional around the disorder-modified ground state, we derive the effective Hamiltonian for the Bogoliubov excitations [1]. Expectation values of physically interesting quantities are obtained by weak-disorder perturbation theory in the Nambu formalism. We extend previous work in the hydrodynamic regime [2] and compute the disorder-broadened dispersion relation for arbitrary condensate healing length, disorder correlation length and excitation wavelength. Observable disorder-induced effects are predicted for the excitation lifetime and localization length, their speed of sound and average density of states.

[1] Gaul and Müller, Europhys. Lett., 83, 10006 (2008)
[2] Gaul, Renner and Müller, Phys. Rev. A, 80, 053620 (2009)

TT 15.6 Tue 15:30 H18

**Impurities in the hardcore Bose-Hubbard model and the xxz model on the triangular lattice** — •Xuefeng Zhang[1,2], Yuchuan Wen[3], and Sebastian Eggert[2] — [1]Institute of theoretical physics of Chinese Academy of Science, Beijing, China — [2]Department of Physics of Univ. Kaiserslautern, Ksierslautern,Germany — [3]Capital Normal university, Beijing, China

The ferromagnetic-antiferromagnetic xxz model is equivalent to the hardcore Bose-Hubbard model. On a triangular lattice frustration effects give rise to interesting physical behavior, including a realization of a supersolid phase. We now consider vacancies in this model using a combination of numerical Monte Carlo simulations and analytic calculations. The solid order and the superfluid density show characteristic changes locally around the impurity depending on the phase. In some cases a single impurity can affect the physical behavior of the entire system. The results show an interesting competition of the different order parameters and illustrate the nature of the excitations in the different phases.

TT 15.7 Tue 15:45 H18

**Numerical analysis of dissipation-induced correlations in 1D bosonic systems** — •Martin Kiffner and Michael Hartmann — Technische Universität München, Physik-Department I, James-Franck-Straße, 85748 Garching, Germany

In one-dimensional systems, bosons can behave with respect to many observables as if they were fermions. This strongly correlated regime of a Tonks-Girardeau (TG) gas regime can be reached for strong repulsive interactions between the particles. Recently, an experiment [1] with cold molecules showed that not only elastic interactions, but even two-particle losses alone are able to create a TG gas. Theoretical work [2] suggests that a dissipation induced TG gas could also be realized with polaritons. The molecular and the polariton system are both described by a master equation for bosons in a one-dimensional setting that experience inelastic two-particle interactions.

Here we present a numerical analysis of this master equation via a time-evolving block-decimation (TEBD) algorithm. In particular, we address the preparation of the strongly correlated regime starting from an uncorrelated state and discuss the time evolution of local as well as non-local observables.

[1] N. Syassen, D. M. Bauer, M. Lettner, T. Volz, D. Dietze, J. J. Garcia-Ripoll, J. I. Cirac, G. Rempe, S. Dürr, Science **320**, 1329 (2009).
[2] M. Kiffner and M. J. Hartmann, arXiv:0908.2055.

TT 15.8 Tue 16:00 H18

**ac-driven atomic quantum motor** — •Sergey Denisov, Alexey V. Ponomarev, and Peter Hanggi — Institute of Physics, University of Augsburg, Germany

Our ac-driven quantum motor [1,2,3] consists of only two different, interacting ultracold atoms placed into a ring-shaped optical lattice. In this setup, while the first atom driven by an external magnetic field carries a current, the second one serves as a quantum starter. We demonstrate that (i) for zero-momentum initial conditions the asymptotic carrier velocity converges to a unique non-zero value, and (ii) the atomic quantum motor is able to perform a work against a constant load.

[1] A. V. Ponomarev, S. Denisov, and P. Hanggi, Phys. Rev. Lett. **102**, 230601 (2009);

[2] A. V. Ponomarev, S. Denisov, and P. Hanggi, arXiv:0909.2813 (in press)

[3] Adrian Cho, feature in Science, web-link: http://sciencenow.sciencemag.org/cgi/content/full/2009/609/1