Program INT13-1b

Quantum Noise

May 13 - 17, 2013

Monday, May 13, 2013

Room C421, Physics/Astronomy Tower

- 11:00 am: Zoran Hadzibabic, Cambridge University

  "Non-equilibrium and transport experiments with atomic BECs"

  I will give an overview of some of our recent experiments on non-equilibrim effects and persistent currents in atomic BECs. First, by tuning the strength of interactions in a 39K gas we have observed a superheated Bose-condensed gas, in which the BEC persists above the equilibrium critical temperature. Bose-Einstein condensation being a second order phase transition, the origin of this effect is qualitatively different from the well known case of the superheating of water. We can quantitatively understand the observed superheating as a purely dynamical non-equilibrium effect. Second, we have performed a series of experiments on persistent currents in both single- and two-spin-component BECs held in a ring-shaped trap. These experiments still leave many open questions, regarding the stochastic nature of phase slips which drive the eventual current dissipation and the interplay between the rotational and spin degrees of freedom.

Tuesday, May 14, 2013

Room C421, Physics/Astronomy Tower

- 11:00 am: Yuval Gefen, Weizmann Institute

  "Hanbury-Brown and Twiss Interference of Anyons"

  A Hanbury Brown and Twiss (HBT) interferometer probes entanglement of initially uncorrelated identical particles. The interference pattern is sensitive to the quantum statistics of the particles involved-- and depends on whether they are bosons or fermions. Here we propose and analyze the HBT interferometry of quasi-particles in the context of the fractional quantum Hall effect. We calculate HBT cross-correlations of Abelian Laughlin anyons that possess fractional statistics, which is neither bosonic nor fermionic. The correlations we calculate exhibit partial bunching similar to bosons, indicating a substantial statistical transmutation from the underlying electronic degrees of freedom. We also ?find qualitative differences between the anyonic signal and the corresponding bosonic or fermionic signals, indicating that anyons cannot be simply thought as intermediate between bosons and fermions.

Wednesday, May 15, 2013

Room C421, Physics/Astronomy Tower

- 11:00 am: Klaus Ensslin, ETH Zurich

  "Quantum noise in quantum dots"

  Quantum dots, or artificial atoms, confine charge carriers in three-dimensional islands in a semiconductor environment. Detailed understanding and exquisite control of the charge and spin state of the electrically tunable charge occupancy have been demonstrated over the years. Quantum dots with best quality for transport experiments areusually realized in n-type AlGaAs/GaAs heterostructures. Novel material systems, such as graphene, nanowires and p-type heterostructures offer unexplored parameter regimes in view of spin-orbit interactions, carrier-carrier interactions and hyperfine coupling between electron and nuclear spins, which might be relevant for future spin qubits realized in quantum dots. With more sophisticated nanotechnology it has become possible to fabricate coupled quantum systems where classical and quantum mechanical coupling and back action is experimentally investigated.

  Time-resolved transport through quantum dots can be measured by using a nearby quantum point contact as a detector. Here we focus on the sequential and co-tunneling regime, where transport and shot noise can be extracted from the counting signal. This enables the measurement of ultra-small currents, quantum shot noise and higher correlations in electronic transport and to compare directly experimental data with the predictions of full counting statistics. Such basic charge counting experiments can be used to measure self-interference of individual electrons, one of the basic concepts of quantum mechanics. Also the fluctuation theorem which is valid in the classical as well as in the quantum regime can experimentally be probed.

Thursday, May 16, 2013

Room C421, Physics/Astronomy Tower

- 11:00 am: Joerg Schmiedmayer, Vienna Center for Quantum Science and Technology

  "Probing Many Body Quantum Systems by Interference"

  One of the challenges in probing many body quantum systems is that there is no general approach to characterize their quantum states. In the last years we developed techniques using the full distribution functions of a quantum observable, in our case the shot to shot variations of the interference patterns [1,2], and the full phase correlation functions to characterize equilibrium states and the dynamics leading to them.

  Our model system to study is a quantum degenerate 1d Bose gas. Interfering two such one dimensional systems results in a fluctuating interference pattern. The noise and correlations in these interference patterns open a probe into the many body states of the 1d Bose gas, its fluctuations and relaxation. In one experiment we study how the coherence created between the two many body systems by the splitting process [3] slowly dies by coupling to the many internal degrees of freedom available. Two distinct regimes are clearly visible: for short length scales the system is characterized by spin diffusion, for long length scales by spin decay [4,5]. After a rapid evolution the distributions approach a steady state, which can be characterized by the establishment of a generalized Gibbs ensemble and pre-thermalization. A detailed look at the phase correlation functions reveals that this relaxed thermal like state is established locally and spreads throughout the system in a light cone like dynamics. Outside this expanding horizon the long-range order persists throughout the entire system [6].

  The experiments in Vienna were supported by the Wittgenstein Prize, the FWF, and the ERC.

[1] A. Polkovnikov, et al. PNAS 103, 6125 (2006); V. Gritsev, et al., Nature Phys. 2, 705 (2006)
[2] S. Hofferberth et al. Nature Physics 4, 489 (2008)
[3] T. Schumm et al. Nature Physics, 1, 57 (2005)
[4] T. Kitagawa et al., Phys. Rev. Lett. 104, 255302 (2010); NJP, 13 073018 (2011)
[5] M. Gring et al., Science 337, 1318 (2012); M. Kuhnert et al. Phys. Rev. Lett 110, 090405 (2013) D. Adu Smith et al. arXiv:1212.4645
[6] T. Langen et al. In preparation (2013)

Friday, May 17, 2013

Room C421, Physics/Astronomy Tower

- 11:00 am: Bertrand Reulet, Université de Sherbrooke

  "Electron shot noise is quantum light"

  We will describe very recent experimental results in which we analyze the quantum shot noise of a dc+ac biased tunnel junction in terms of quantum optics. In particular, we will show: 1) the existence of a fourth cumulant in the current fluctuations, which corresponds to intensity-intensity correlations of light, down to the single photon level; 2) the existence of squeezing, i.e. current fluctuations below that of vacuum, in a phase sensitive noise measurement.

INT Program Participants May 13 - 17, 2013

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