DY 6: Statistical Physics far from Thermal Equilibrium - Part II

Time: Monday 15:00–17:30 Location: ZEU 160

Invited Talk DY 6.1 Mon 15:00 ZEU 160

Odd Bose condensation far from equilibrium — Daniel Vorberg[1,2], Waltraut Wustmann[1,2], Roland Ketzmerick[1,2], and •André Eckardt[1] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden, Germany — [2]Technische Universität Dresden, Institut für Theoretische Physik, 01187 Dresden, Germany

Bose-Einstein condensation, the macroscopic occupation of a single quantum state, appears in equilibrium quantum statistical mechanics. We show that even when a degenerate Bose gas is driven into a steady state far from equilibrium, e.g. by time-periodic driving, Bose-Einstein condensation survives in a generalized form [1]: the unambiguous selection of an odd number of states acquiring large occupations.

We study the effect in driven-dissipative model systems and propose a quantum switch for heat conductivity based on shifting between one and three *Bose selected* states.

[1] D Vorberg, W Wustmann, R Ketzmerick, and A Eckardt, Phys. Rev. Lett. **111**, 240405 (2013)

DY 6.2 Mon 15:30 ZEU 160

Superfluid Turbulence, Vortex Dynamics, and Universality in Ultracold Bose Gases — •Markus Karl[1,2], Boris Nowak[1,2], and Thomas Gasenzer[1,2] — [1]Institut für Theoretische Physik, Ruprecht-Karls-Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, 64291 Darmstadt, Germany

Inspired by turbulence in classical hydrodynamics great efforts have been made in recent years to investigate and describe its quantum analogon in superfluids such as Helium and Bose–Einstein condensates. Here the intriguing difference to classical turbulence is that vortical flows can appear only quantised and are carried by particle-like excitations, namely vortices. Nevertheless, characteristic scaling laws for the kinetic energy appear also in quantum turbulent systems, establishing a notion of universality similar to Kolmogorov turbulence in classical hydrodynamics. In this talk we discuss quantum turbulence in far-from-equilibrium Bose gases as a result of interacting vortices and tangles of vortex lines. The emergence of universal scaling laws for the kinetic energy and the occupation spectrum respectively, $n(k) \sim k^{-\zeta}$, is demonstrated using semi-classical simulations and explained with the intrinsic scaling properties of the building blocks of quantum turbulence, *i.e.* the vortices. In addition the occupation spectra for the dynamically evolving Bose gas are analysed using quantum-field theoretic methods based on effective-action techniques. This approach leads to a close connection between steady universal scaling solutions and stationary fluxes of energy or particles in momentum space.

DY 6.3 Mon 15:45 ZEU 160

Heat transport through spin chains — •Gernot Schaller[1], Malte Vogl[2], and Tobias Brandes[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Germany — [2]Max-Planck-Institut für Physik Komplexer Systeme, Dresden, Germany

Starting from microscopic spin-boson-type models we compare the heat transport through closed and open spin chains with and without disorder. Extending previous work [1] we calculate transport characteristics via locally coupling two heat reservoirs to the spin chain. Since for the closed spin chain many degeneracies are present, we compare results from the full quantum master equation approach with results from the rate equation approach. In both cases we find that transport is strongly dependent on the phase of the spin chain.

[1] M. Vogl, G. Schaller, and T. Brandes, PRL **109**, 240402 (2012).

DY 6.4 Mon 16:00 ZEU 160

Thermodynamics of Quantum-Jump-Conditioned Feedback Control — •Philipp Strasberg[1], Gernot Schaller[1], Tobias Brandes[1], and Massimiliano Esposito[2] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, D-10623 Berlin, Germany — [2]Complex Systems and Statistical Mechanics, University of Luxembourg, L-1511 Luxembourg, Luxembourg

We consider open quantum systems weakly coupled to thermal reservoirs and subjected to quantum feedback operations triggered with or without delay by monitored quantum jumps. We establish a thermodynamic description of such systems and analyze how the first and second law of thermodynamics are modified by the feedback. We apply our formalism to study the efficiency of a qubit subjected to a quantum feedback control and operating as a heat pump between two reservoirs. We also demonstrate that quantum feedbacks can be used to stabilize coherences in nonequilibrium stationary states which in some cases may even become pure quantum states.

Ref.: arXiv:1305.6589 (accepted by Phys. Rev. E)

DY 6.5 Mon 16:15 ZEU 160

Quantum critical temperature of a modulated oscillator — Lingzhen Guo[1], Vittorio Peano[2], •Michael Marthaler[1], and Mark Dykman[3] — [1]Institut für Theoretische Festkörperphysik, KIT, Karlsruhe — [2]Institute for Theoretical Physics II, University of Erlangen-Nuremberg, Erlangen — [3]Department of Physics,Department of Physics and Astronomy, Michigan State University, East Lansing

We show that the rate of switching between the vibrational states of a modulated nonlinear oscillator is characterized by a quantum critical temperature $T_c \propto \hbar^2$. The rate is independent of T for $T < T_c$. Above T_c there emerges a quantum crossover region where the slope of the logarithm of the distribution over the oscillator states displays a kink and the switching rate has the Arrhenius form with the activation energy independent of the modulation. The results demonstrate the limitations of the real-time instanton theory of switching in systems lacking detailed balance.

15 min break

DY 6.6 Mon 16:45 ZEU 160

Observable most probable trajectories of quantum switching in modulated oscillator — •Vittorio Peano[1] and Mark Dykman[2] — [1]Friedrich Alexander Universität Erlangen — [2]Michigan State University

Quantum fluctuations lead to a finite width of the distribution of a modulated system over its quasienergy (Floquet) states even for zero temperature of the bath to which the system is coupled. We study the resulting distribution for a periodically modulated oscillator. Of special interest are large rare fluctuations responsible for the tail of the distribution over quasienergy and for switching between metastable states of forced vibrations. We find the most probable paths followed by the quasienergy in rare events, including switching. Along with the switching rates, such paths are observable characteristics of quantum fluctuations. As we show, they can change discontinuously once the detailed balance condition is broken (leading to the quantum crossover discussed in [1]). Knowledge of such paths suggests a new way of quantum control of rare events.

[1] see M. Marthaler contribution

DY 6.7 Mon 17:00 ZEU 160

Elektronischer Energietransport in Metallen fernab vom thermischen Gleichgewicht — •Orkhan Osmani, Mourad El Kharrazi und Marika Schleberger — Universität Duisburg-Essen, Fakultät für Physik

Formal lässt sich der Energietransport mittels kinematischer Modelle wie der Monte Carlo Methode oder der Boltzmanngleichung beschreiben, wobei der mikroskopische Zustand des Systems durch die Orte und Impulse aller Teilchen definiert wird. In solchen Modellen müssen für die zeitliche Entwicklung eines mikroskopischen Systems charakteristische Größen wie Stoßraten für alle physikalischen Prozesse, wie z.B. Elektron-Elektron oder Elektron-Phonon Stöße, explizit bekannt sein. Jedoch sind solche Modelle durch den hohen numerischen Aufwand oft ungeeignet, große Systeme unter vertretbarem Zeitaufwand zu beschreiben. Eine häufig verwendete Vereinfachung ist es, den Transport mittels einer Wärmeleitungsgleichung zu beschreiben, so dass der Zustand nun makroskopisch durch die Temperatur definiert ist. Hierbei ist die zeitliche Entwicklung des Systems durch die Wärmekapazität und Wärmeleitfähigkeit gegeben. Während der Übergang vom mikroskopischen zur makroskopischen Beschreibung für den Fall einer Gleichgewichtsverteilungsfunktion immer möglich ist, ist der Übergang für eine Nichtgleichgewichtsverteilung fragwürdig. Um diese Frage zu klären, haben wir den Energietransport in Metallen für verschiedene Nichtgleichgewichtsverteilungen mittels der Boltzmanngleichung, un-

ter Berücksichtigung der El.-El.-Stöße, untersucht und anschließend mit einer Wärmeleitungsgleichung verglichen.

DY 6.8 Mon 17:15 ZEU 160

Formation of correlations at short time scales — •Klaus Morawetz — Münster University of Applied Sciences, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics (IIP), Avenida Odilon Gomes de Lima 1722, 59078-400 Natal, Brazil — Max-Planck- Institute for the Physics of Complex Systems, 01187 Dresden, Germany

Using a conserving relaxation-time approximation an analytic formula is derived which describes the time dependence of the formation of correlations in two distinct physical systems: (i) the collective modes in a plasma created by a short intense laser pulse with an additional external electric field bias reproducing experimental universal features of the transient time behaviour of femtosecond spectroscopy (Phys. Rev. B 72 (2005) 233203) and (ii) the population dynamics of cold atomic gases on an optical lattice after a sudden quench.