TT 81: Nonequilibrium Quantum Many-Body Systems III

Time: Thursday 9:30–11:15 Location: H 3010

TT 81.1 Thu 9:30 H 3010

Dynamical Quantum Phase Transitions in Systems with Continuous Symmetry Breaking — •Simon Weidinger[1], Markus Heyl[2,1], Alessandro Silva[3], and Michael Knap[1] — [1]Department of Physics and Institute of Advanced Study, Technical University of Munich, 85748 Garching, Germany — [2]Max-Planck-Institute für Physik komplexer Systeme, 01187 Dresden, Germany — [3]SISSA - International School for Advanced Studies, via Bonomea 265, 34136 Trieste, Italy

Interacting many-body systems that are driven far away from equilibrium can exhibit phase transitions between dynamically emerging quantum phases, which manifest as singularities in the Loschmidt echo. Whether and under which conditions such dynamical transitions occur in higher-dimensional systems with spontaneously broken continuous symmetries is largely elusive thus far. Here, we study the dynamics of the Loschmidt echo in the three dimensional O(N) model following a quantum quench from a symmetry breaking initial state. The O(N) model exhibits a dynamical transition in the asymptotic steady state, separating two phases with a finite and vanishing order parameter, that is associated with the broken symmetry. We analytically calculate the rate function of the Loschmidt echo and find that it exhibits periodic kink singularities when this dynamical steady-state transition is crossed. The singularities arise exactly at the zero-crossings of the oscillating order parameter. As a consequence, the appearance of the kink singularities in the transient dynamics is directly linked to a dynamical transition in the order parameter.

TT 81.2 Thu 9:45 H 3010

Constructing effective free energies for dynamical quantum phase transitions in the transverse-field Ising chain — •Daniele Trapin and Markus Heyl — Max-Planck-Institut fur Physik komplexer Systeme, Nothnitzer Strasse 38, 01187-Dresden, Germany

Phase transitions play a central role in equilibrium many-body systems. The theory of dynamical quantum phase transitions represents an attempt to extend the notion of phase transition to the far from equilibrium regime. As opposed to conventional transitions which are driven by a control parameter such as temperature of pressure, these dynamical transitions occur as a function of time with physical quantities becoming nonanalytic at critical times. While there are many formal analogies to conventional transitions, it is a major question to which extent it is possible to formulate a nonequilibrium counterpart to a Landau-Ginzburg theory. In this work we address this problem for quantum quenches in a one-dimensional transverse-field Ising model. We construct an effective free energy which due to unitary time evolution becomes a complex quantity. This transforms the conventional minimization principle into a saddle-point equation in the complex plane of the order parameter. We study this effective free energy in the vicinity of the dynamical quantum phase transition by performing an expansion in terms of the complex magnetization.

TT 81.3 Thu 10:00 H 3010

Non-Markovian Decay of Nuclear Spins Coupled to Itinerant Electrons — •Stephanie Matern and Bernd Brauncker — SUPA, School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews, Fife KY16 9SS, United Kingdom

We study the full time evolution of a nuclear spin coupled to itinerant electrons through the hyperfine interaction, with a particular focus on memory effects leading to a non-Markovian behaviour. We show that even a noninteracting electron system causes a notable memory effect due to the restriction of fluctuations by the Fermi surface. The resulting short time dynamics of the nuclear spin is dominated by a logarithmic, temperature independent decay before crossing over to the standard, thermally induced exponential decay. But even at the longer time scales the initial non-Markovian decay causes a systematic reduction of the decay amplitude that should be detectable. Our approach is based on an expansion of the exact Nakashima-Zwanzig equation in the hyperfine coupling constant, set up to preserve the analytical structure of the memory kernel that causes the non-Markovian behaviour. Our results are analytical and describe the full time range from the novel non-Markovian contributions to the well-known exponential decay expressions.

TT 81.4 Thu 10:15 H 3010

Quantum Quench Dynamics in the bond-alternating Heisenberg Model — •Mirco Marahrens — University of Stuttgart, Institute for Functional Matter and Quantum Technologies

We studying the bond-alternating Heisenberg model regarding its quench dynamics between different symmetry protected topological phases, namely the odd and even degenerated Haldane phases, and quenches to the trivial phase. Therefore we are using the Density Matrix Renormalization Group in the formalism of uniform matrix product states and a time evolution scheme purely based on matrix product operators constructed by finite state machines.

TT 81.5 Thu 10:30 H 3010

Boundary-driven Heisenberg chain in the long-range interacting regime: Robustness against far-from-equilibrium effects — Leon Droenner and •Alexander Carmele — Technische Universität Berlin, Institut für Theoretische Physik, Hardenbergstr. 36, 10623 Berlin

The discovery of disorder induced localization in the presence of interactions,known as many-body localization, opened a new field of theoretical and experimental investigations. A common generic model to study such effects is the disordered isotropic Heisenberg spin-chain [1]. By applying two magnetic boundary reservoirs, we drive the system out of equilibrium and induce a nonzero steady-state current [2]. The long-range coupled chain shows nearly ballistic transport and linear response for all potential differences of the external reservoirs. In contrast, the common isotropic nearest-neighbor coupling shows negative differential conductivity and a transition from diffusive to subdiffusive transport for a far-from-equilibrium driving. We find for the disordered long-range coupled XXZ chain, any change in the transport behavior is independent of the potential difference and the coupling strengths of the external reservoirs [2]. Therefore, to distinguish many-body localization as an effect of disorder from the spin-blockade, long-range coupling provides a clear understanding of MBL for boundary-driven systems as it is robust against far-from-equilibrium effects.

[1] M. Znidaric et al, Phys. Rev. Lett. 117, 040601 (2016).
[2] L. Droenner and A. Carmele Phys. Rev. B 96, 184421 (2017).

TT 81.6 Thu 10:45 H 3010

Non-equilibrium Real-space DMFT for correlated heterostuctures — •Irakli Titvinidze, Max Sorantin, Antonius Dorda, Wolfgang von der Linden, and Enrico Arrigoni — Institute of theoretical and computational physics, Graz Univeristy of Technology, 8010 Graz, Austria.

We consider a system consisting of correlated monoatomic layers, sandwiched between two metallic leads. In addition to the local Hubbard interaction we also take the long-range Coulomb interaction into account, which causes electronic charge reconstruction not only in the correlated layers but also in the leads. The non-equilibrium situation is driven by applying a bias-voltage to the leads. We investigate the steady-state behavior of the system. In particular, we present results for the steady-state current, spectral functions, and electronic charge reconstruction. Depending on the particular parameters we either observe a capacitor-like behavior or one dominated by charge transport.

In order to investigate steady-state properties we use Non-equilibrium real-space dynamical mean-field theory (R-DMFT) [1-3] combined with the Poisson equation, both solved in a self-consistent fashion. To account for the charge reconstruction in the leads we include some lead layers explicitly in R-DMFT in addition to the correlated layers.

[1] E. Arrigoni, M. Knap, and W. von der Linden, Phys. Rev. Lett **110**, 086403 (2013).
[2] I. Titvinidze, A. Dorda, W. von der Linden, and A. Arrigoni, Phys. Rev. B **94**, 245142 (2016).
[3] J.K. Freericks, Phys. Rev. B **70**, 195342 (2004).

TT 81.7 Thu 11:00 H 3010

From two Algebraic Bethe Ansätze to the dynamics of Dicke-Jaynes-Cummings-Gaudin quantum integrable models through eigenvalue-based determinants — Hugo Tschirhart[1], •Alexandre Faribault[2], and Thierry Platini[3] — [1]Université du Luxembourg, Luxembourg, Luxembourg — [2]Université de Lorraine, Nancy, France — [3]Coventry University, Coventry, United Kingdoms

The work in question was inspired by precedent results on the Gaudin models (which are integrable) for spins-1/2 only which, by a change of variables in the algebraic Bethe equations, manage to considerably simplify the numerical treatment of such models.

This numerical optimisation is carried out by the construction of determinants, only depending on the previously mentioned variables, for every scalar products appearing in the expression of the mean value of an observable of interest at a given time.

By showing it is possible to use the Quantum Inverse Scattering Method, even when the vacuum state is not eigenstate of the transfer matrix, the previous results concerning spins-1/2 only are generalised to models including an additional spin-boson interaction.

A numerical treatment of systems describing the interaction of many spins-1/2 with a single bosonic mode has been done. We studied through it the time evolution of bosonic occupation and of local magnetisation for two different Hamiltonians, the Tavis-Cummings Hamiltonian and a central spin-like Hamiltonian. We learn that the dynamics of these systems, relaxing from an initial state to a stationary state, leads to a superradiant-like state for certain initial states.