Q 3: Quantengase: Dynamik in Gittern

Zeit: Montag 10:45–12:30 Raum: VMP 6 HS-A

Q 3.1 Mo 10:45 VMP 6 HS-A

Magnetism, coherent many-particle dynamics, and relaxation with ultracold bosons in optical superlattices — Thomas Barthel[1], •Christian Kasztelan[1], Ian P. McCulloch[2], and Ulrich Schollwöck[1] — [1]Institute for Theoretical Physics C, RWTH Aachen University, 52056 Aachen, Germany — [2]School of Physical Sciences, The University of Queensland. Brisbane, QLD 4072, Australia

We study a particular setup of an ultracold two-species boson gas in an optical superlattice. This realizes in a certain parameter regime actually the physics of spin-1/2 Heisenberg magnets describing the second order hopping processes. Tuning of the superlattice allows for controlling the effect of fast first order processes versus the slower second order ones. We provide the evolution of typical experimentally available observables by the density-matrix renormalization-group method. The validity of the description via the Heisenberg model is studied numerically and analytically. Contrary to the case of recently realized coherent two-particle dynamics (isolated double wells), relaxation of local observables can be observed. The tunability between the Bose-Hubbard model and the Heisenberg model in this setup could be used to study experimentally the differences in equilibration processes for nonintegrable and Bethe ansatz integrable models.

[1] T. Barthel, C. Kasztelan, I. P. McCulloch and U. Schollwöck, arXiv:0809.5141 (2008)

Q 3.2 Mo 11:00 VMP 6 HS-A

Relaxation dynamics in quasi one-dimensional cold gases — •Dominik Muth and Michael Fleischhauer — Fachbereich Physik, Technische Universität Kaiserslautern, Germany

Since the first realisation of a Bose-Einstein condensate in cold atomic gases, experimental methods have been much improved. Today also the dynamics of quantum degenerate gases can be observed and deep optical lattices or atom chips provide access to the quasi one-dimensional regime. While one-dimensional quantum gases with local interactions are integrable even for finite interaction strength, experiments necessarily contain small distortions due to transversal excitations in the confinement or coupling between different one-dimensional cells. These destroy integrability and make the system relax into a thermal state, given by the usual canonical ensemble. We investigate theoretically the connection between the strength of the distortions and the rate of thermalization. The analytical results are complemented with numerical simulations using the Time Evolving Block Decimation algorithm, a powerful tool for one-dimensional quantum systems, that allows us to go beyond the regime covered by perturbation theory.

Q 3.3 Mo 11:15 VMP 6 HS-A

Far-From-Equilibrium Dynamics of an Ultracold Fermi Gas — •Matthias Kronenwett and Thomas Gasenzer — Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg

We study the dynamics of ultracold Fermi gases far from thermal equilibrium. We employ a functional-integral approach based on the Schwinger-Keldysh closed time path integral to derive the two-particle irreducible (2PI) effective action. From this, the two-point correlation functions are determined self-consistently. The action is expanded in inverse powers of $\mathcal{N}$, where $\mathcal{N}$ is the number of spin 1/2 fermion flavors. The dynamic equations are derived in next-to-leading order of this expansion for a single flavor Fermi gas. This approach reaches far beyond mean-field theory and includes quantum statistical aspects of equilibration dynamics. It enables to describe, e.g., the dynamical evolution of trapped Fermi gases in optical lattices, as well as the BEC-BCS crossover dynamics. We present results on the dynamics of a 1D Fermi gas initally prepared far away from equilibrium.

Q 3.4 Mo 11:30 VMP 6 HS-A

Dynamical properties of solitonic eigenstates of the Bose-Hubbard Hamiltonian — •Hannah Venzl[1], Tobias Zech[1], Bartłomiej Oleś[2], Moritz Hiller[1], Florian Mintert[1], and Andreas Buchleitner[1] — [1]Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg, Germany — [2]Marian Smoluchowski Institute of Physics and Mark Kac Complex Systems Research Center, Jagiellonian University, Reymonta 4, 30-059 Kraków, Poland

We show the emergence of solitonic eigenstates in the Bose-Hubbard Hamiltonian with an additional tilt in a regime where the spectrum obeys chaotic level statistics. Those states show robust behavior in the sense that they couple weakly to the chaotic background. By driving the system with a time-dependent tilt we investigate the dynamical behavior of those solitonic eigenstates and show that their stability is strongly enhanced as compared to states from the chaotic background. We discuss the analogy of the solitonic submanifold to regular islands embedded in a chaotic sea.

Q 3.5 Mo 11:45 VMP 6 HS-A

Collapse and Revival of Matter Waves in Bosonic Optical Lattices — •Francisco Ednilson Alves dos Santos[1] and Axel Pelster[1,2] — [1]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg, Germany

Within the Ginzburg-Landau theory of the Bose-Hubbard model [1], we derive the underlying equation of motion which describes the dynamics of the condensate wave function. With this we describe theoretically the experimental results of Ref. [2], in particular the apparent damping effect which completely extinguishes the matter wave after a characteristic time scale. We show that, due to the overall harmonic potential which confines the atoms inside a finite volume, the condensate wave function oscillates with frequencies which vary slightly from site to site. As time elapses, the values of the matter wave at two spatially separated points in the lattice become out of phase. This destroys the coherence of the condensate after a certain damping time which is associated with the harmonic frequency of the external magnetic trap.

[1] B. Bradlyn, F.E.A. dos Santos, and A. Pelster, Phys. Rev. A (in press), eprint: `arXiv:0809.0706`.

[2] M. Greiner, O. Mandel, T. W. Hänsch, and I. Bloch, Nature, **419**, 51 (2002).

Q 3.6 Mo 12:00 VMP 6 HS-A

Exact local relaxation in a class of quantum lattice systems: Central limit theorems and experimentally accessible signatures — •Marcus Cramer[1], Andreas Flesch[2], Ulrich Schollwöck[2], and Jens Eisert[3] — [1]Imperial College London, UK — [2]RWTH Aachen, Germany — [3]Universität Potsdam, Germany

A reasonable physical intuition in the study of interacting quantum systems says that, independent of the initial state, the system will tend to equilibrate. We present a setting in which relaxation to a steady state is provably exact, namely for the Bose-Hubbard model where the system is quenched from a Mott quantum phase to the strong superfluid regime. We find that the evolving state locally relaxes to a steady state with maximum entropy constrained by the constants of motion [1]. Our argument includes a quantum central limit theorem and exploits the finite speed of information propagation. In addition, we present a setting—atoms in optical super-lattices—in which one can experimentally probe signatures of this local relaxation without the need of addressing single sites [2]. This opens up a way to explore the convergence of subsystems to maximum entropy states in quenched quantum many-body systems with present technology. We also outline generalizations to arbitrary initial states and quasi-free dynamics.

[1] M. Cramer, C.M. Dawson, J. Eisert, T.J. Osborne, Phys. Rev. Lett. **100**, 030602 (2008).

[2] M. Cramer, A. Flesch, I.P. McCulloch, U. Schollwoeck, J. Eisert, Phys. Rev. Lett. **101**, 063001 (2008).

Q 3.7 Mo 12:15 VMP 6 HS-A

Statistics of Schmidt coefficients and the simulability of complex quantum systems — •Hannah Venzl[1], Andrew J. Daley[2,3], Florian Mintert[1], and Andreas Buchleitner[1] — [1]Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg, Germany — [2]Institut für Theoretische Physik, Universität Innsbruck, Technikerstr. 25, 6020 Innsbruck, Austria — [3]Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, 6020 Innsbruck, Austria

We show that the transition from regular to chaotic spectral statistics in interacting many-body quantum systems has an unambiguous signature in the distribution of Schmidt coefficients dynamically generated from generic initial states. The characteristic redistribution that is observed on the transition to chaotic dynamics confirms that chaotic many body systems can not be described efficiently by local bases [1] what implies that techniques like the time-dependent Density Matrix Renormalization Group algorithm [2] loose their efficiency. We investigate these mechanisms on the tilted Bose-Hubbard model. However, the emergence of universal spectral properties allows to translate our conclusions to generic many-body quantum systems.

[1] H. Venzl, A. J. Daley, F. Mintert, and A. Buchleitner, arXiv:0808.3911

[2] G. Vidal, Phys. Rev. Lett. **91**, 147902 (2003)