Q 18: Quantum Gases (Bosons) II

Time: Monday 14:00–16:00 Location: K 2.020

Q 18.1 Mon 14:00 K 2.020

Observation of parametric instabilities in 1D interacting shaken optical lattice systems — •Jakob Näger[1,2], Karen Wintersperger[1,2], Marin Bokov[3], Martin Reitter[1,2], Samuel Lellouch[4], Ulrich Schneider[5], Nathan Goldman[4], Immanuel Bloch[1,2], and Monika Aidelsburger[1,2] — [1]Ludwig-Maximilians-Universität München, Schellingstr. 4, 80799 München — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, 85748 Garching — [3]Boston University, 590 Commonwealth Ave., Boston, MA 02215 — [4]Université Libre de Bruxelles, CP 231, Campus Plaine, 1050 Brussels, Belgium — [5]University of Cambridge, Cambridge, UK

We study the dynamics of BECs in a driven optical 1D lattice using 39K atoms that have an accessible Feshbach resonance allowing for the control of interactions. The short-time dynamics is mostly dominated by parametric instabilities [1] and can be well described within Bogoliubov theory. At longer times this description seizes to be accurate and the dynamics can be captured by a Fermi*s golden rule approach [2]. We observe the transition between the two regimes for different shaking parameters and interactions. Also, we compare the quasimomentum of the most unstable modes to the values expected from Bogoliubov theory.

[1] S. Lellouch et al., PRX 7, 021015, 2017

[2] M. Reitter et al., PRL 119, 200402, 2017

Q 18.2 Mon 14:15 K 2.020

Creating a superfluid by kinetically driving a Mott insulator — •Gregor Pieplow, Charles E. Creffield, and Fernando Sols — Departamento de Física de Materiales, Universidad Complutense de Madrid, E-28040 Madrid, Spain

We study the effect of time-periodically varying the hopping amplitude (which we term “kinetic driving”) in a one-dimensional Bose-Hubbard model, such that the time-averaged hopping is zero. By using Floquet analysis we derive a static effective Hamiltonian in which nearest-neighbor single-particle hopping processes are suppressed, but all even higher-order processes are allowed. Unusual many-body features arise from the combined effect of nonlocal interactions and correlated tunneling. At a critical value of the driving, the system passes from a Mott insulator to a superfluid formed by two quasi-condensates with opposite nonzero momenta. A many-body cat state combining the two macroscopically-occupied momentum eigenstates emerges even with hard-wall boundary conditions. We also explore Bogoliubov-de Gennes theory, which allows to infer the nature of the excitations of the fragmented superfluid. This work shows how driving of the hopping energy provides a novel form of Floquet engineering, which enables atypical Hamiltonians and exotic states of matter to be produced and controlled.

Q 18.3 Mon 14:30 K 2.020

Periodically Modulated Interaction of Two Species Bosons on the Optical Lattice — •Shijie Hu[1], Tao Wang[2], Axel Pelster[1], Sebastian Eggert[1], and Xue-Feng Zhang[3] — [1]Department of Physics and Research Center OPTIMAS, Technische Universität Kaiserslautern, Germany — [2]Wuhan Institute of Technology, Hubei, China — [3]Chongqing University, Chongqing, China

Systems far away from equilibrium show interesting new phenomena. In this work, we propose to generate a periodically driven system of two species of bosons on a one-dimensional optical lattice by modulating the magnetic field nearby a Feshbach resonance. We further investigate properties of this system by various numerical methods. Surprisingly, at zero-temperature we found that the driving is not always suppressing the superfluid order; instead it can abnormally enhance the order in a specific parameter region. In other regions, the driving can induce a new kind of superfluid order because the cooperation of particles and gauge phases. The results are consistent with a rigorous solution at an integrable point. We also discuss the behaviour at finite temperatures.

Q 18.4 Mon 14:45 K 2.020

Generation of robust entangled states in a non-Hermitian periodically driven two-band Bose-Hubbard system — Carlos A. Parra-Murillo[1], Manuel H. Muñoz-Arias[1], •Javier Madroñero[1], and Sandro Wimberger[2] — [1]Physics Department, Universidad del Valle, Cali, Colombia — [2]Dipartimento di Scienze Matematiche, Fisiche e Informatiche Università di Parma, Italy

A many-body Wannier-Stark system coupled to an effective reservoir is studied within a non-Hermitian approach in the presence of a periodic driving. We show how the interplay of dissipation and driving dynamically induces a subspace of states which are very robust against dissipation. We numerically probe the structure of these asymptotic states and their robustness to imperfections in the initial-state preparation and to the size of the system. Moreover, the asymptotic states are found to be strongly entangled making them interesting for further applications.

Q 18.5 Mon 15:00 K 2.020

Periodic-Orbit Classification in Quantum Many-Body Systems — •Daniel Waltner, Maram Akila, Petr Braun, Boris Gutkin, and Thomas Guhr — Faculty of Physics, University of Duisburg-Essen, Duisburg, Germany

Semiclassical theories connect classical and quantum systems. They relate classical periodic orbits on the one side and the quantum spectrum on the other by trace formulae. In the past, there has been huge interest in obtaining periodic orbit spectra for single-particle quantum systems (for example for the hydrogen atom in a strong magnetic field and billiards). Here, the Fourier transformation of the trace formula was compared with the periodic orbits calculated by the classical equations of motion. In this presentation, I demonstrate how to generalize this comparison to a many-particle system considering a kicked spin chain with nearest neighbor Ising coupling and on-site kicked magnetic field. Here, we face the problem that the dimension of the quantum Hilbert space and the number of periodic orbits is too large to apply the conventional methods used for single-particle systems. We show how to overcome the problem arising from the large Hilbert space dimension by a duality relation and identify dominant contributions to the quantum spectrum arising from collective classical motion of the spins.

Reference: M. Akila, D. Waltner, B. Gutkin, P. Braun, T. Guhr, Phys. Rev. Lett. **118** (2017) 164101

Q 18.6 Mon 15:15 K 2.020

A Diagrammatic Monte Carlo study of a composite, rotating impurity — •Giacomo Bighin[1], Timur Tscherbul[2], and Mikhail Lemeshko[1] — [1]IST Austria (Institute of Science and Technology Austria), Am Campus 1, 3400 Klosterneuburg, Austria — [2]Department of Physics, University of Nevada, Reno, NV, 89557, USA

The angulon quasiparticle [1], formalizing the concept of a composite, rotating impurity interacting with a quantum many-body environment, has proven useful in the description of several experimental settings: cold molecules in a Bose-Einstein condensate or embedded in helium nanodroplets, electronic excitations in a BEC or in a solid.

Recently it has been shown that the angulon can be understood using a diagrammatic formalism [2], fusing Feynman diagrams with the angular momentum diagrams used in atomic and nuclear structure calculations. Based on this formalism, we present a comprehensive Diagrammatic Monte Carlo (DiagMC) study of the angulon.

The techniques we introduce open up the possibility of studying the angulon at arbitrary coupling strength, and are compared with existing weak- and strong- coupling analytical theories for the angulon [1]. The present work paves the way for using DiagMC techniques in the study of many-body systems comprising complex, rotating impurities, establishing a far-reaching connection between DiagMC techniques and molecular simulations.

[1] R. Schmidt and M. Lemeshko, Phys. Rev. Lett. 114, 203001 (2015) and Phys. Rev. X 6, 011012 (2016). [2] G. Bighin and M. Lemeshko, Phys. Rev. B 96, 419 (2017).

Q 18.7 Mon 15:30 K 2.020

Is there a Floquet Lindbladian? — •Alexander Schnell[1,3], André Eckardt[1,3], and Sergey Denisov[2,3] — [1]Max Planck Institut für Physik komplexer Systeme, Dresden, Germany — [2]Universität Augsburg, Germany — [3]Institute for Basic Science, Center for Theoretical Physics of Complex Systems, Daejeon, South Korea

It is well known that the stroboscopic dynamics of a time-periodically driven closed quantum system can be mapped to the dynamics of a time-independent Floquet Hamiltonian acting on the identical Hilbert space. For cold atom systems this concept has been applied successfully to shaken optical lattices, giving rise to e.g. artificial gauge fields for charge neutral atoms [1].

We address the question if a similar mapping exists for time-periodically driven open quantum systems, whose dynamics is governed by a Lindblad superoperator. We find that for a simple qubit model there are extensive parameter regions where a mapping to a time-independent Floquet Lindbladian is possible, and extensive regions where it is not. In the regions where this mapping fails the stroboscopic dynamics can only be reproduced by a time-homogeneous evolution that is non-markovian.

[1] A. Eckardt, Rev. Mod. Phys. 89, 011004 (2017)

Q 18.8 Mon 15:45 K 2.020

Excitation transport in networks with an energy gradient, modelled after photosynthetic systems — Hlér Kristjánsson[1,2], Jonathan Brugger[1], Gabriel Dufour[1], •Christian Scheppach[1], and Andreas Buchleitner[1] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg i. Br., Germany — [2]Department of Physics, Imperial College London, U.K.

In photosynthesis, a photon is absorbed by a light-harvesting antenna, and the energy excitation is transported along several chlorophylls to a reaction centre. Recently, there has been much discussion whether a quantum mechanically coherent description of the transport process is necessary to understand it. This motivates our theoretical study of excitation transport through networks of two-level systems. To account for the limited experimental knowledge of the parameters, as well as the natural variability in biological systems, we study statistical ensembles of networks and look for design principles ensuring efficient transport. When the input and output site of the network have the same energy, "centrosymmetry" of the Hamiltonian and a "dominant doublet" are design principles enhancing the probability of efficient transport. In the more realistic case of an energy difference between the input and output site, external vibrations can bridge the gap, and are treated with Floquet theory. Here, one can demand a "dominant Floquet doublet", and "anticentrosymmetry" can be imposed in the extended Floquet-Hilbert space.