Q 40: Transport and Localization of interacting Bosons 1

Time: Wednesday 16:30–18:00 Location: HSZ 02

Q 40.1 Wed 16:30 HSZ 02

Observation of Absolute Negative Mobility in Driven Quantum Systems — •Tobias Salger[1], Sebastian Kling[1], Sergey Denisov[2], Alexey Ponomarev[2], Peter Hänggi[2], and Martin Weitz[1] — [1]Institut für Angewandte Physik, Wegelerstrasse 8, 53115 Bonn — [2]Institut für Physik, Universitätsstrasse 1, 86135 Augsburg

Here we report on the observation of absolute negative mobility (ANM) of a Bose-Einstein condensate in an ac-driven quantum system. This effect describes the paradoxial situation, when the motion of a particle is always in oppositve direction to an applied external gradient field. Based on successful experiments, demonstrating a directed motion of a Bose-Einstein condensate in a Hamiltonian quantum ratchet, we investigate the dynamics of atoms when exerted to an external bias field [1].

Up to now, the presence of strong decoherence mechanisms has been considered to be crucial for absolute negative mobility [2]. However here we demonstrate for the first time that this phenomenon can also be observed in a coherent quantum system. Our experimental results are in good agreement with a theoretical model, based on numerical simulations.

[1] T. Salger et al., Science **326**, 1241 (2009)
[2] A. Ros et al., Nature **436**, 928 (2005)

Q 40.2 Wed 16:45 HSZ 02

Direct observation of quasi-local relaxation with strongly correlated bosons in an optical lattice — •Stefan Trotzky[1,2,3], Yu-Ao Chen[1,2,3], Andreas Flesch[4], Ian P. McCulloch[5], Ulrich Schollwöck[1,6], Jens Eisert[6,7], and Immanuel Bloch[1,2,3] — [1]Ludwig-Maximilians Universität München — [2]MPI für Quantenoptik, Garching — [3]Johannes-Gutenberg Universität Mainz — [4]Forschungszentrum Jülich — [5]University of Queensland — [6]Institute for Advanced Study, Berlin — [7]Universität Potsdam

The question of how closed quantum systems far from equilibrium come to rest lies at the heart of statistical mechanics. We report the experimental observation of the relaxation dynamics of a one-dimensional bosonic density wave in an optical lattice. Using an optical superlattice, we are able to load Bose-Hubbard chains with each second lattice site occupied. Furthermore, the superlattice allows us to monitor the non-equilibrium dynamics emerging after rapidly switching on the tunnel coupling along the chain in terms of quasi-local densities, currents and correlations. We find a rapid relaxation of all these quantities to steady-state values compatible with those of a maximum entropy state. We compare the experimental results to parameter free time-dependent DMRG simulations, finding excellent agreement. The system thus can be seen as an accurate dynamical quantum simulator for the systematic study of equilibration phenomena in strongly correlated many-body systems.

Q 40.3 Wed 17:00 HSZ 02

Observation of subdiffusion of a disordered interacting system — •Eleonora Lucioni[1], Benjamin Deissler[1], Luca Tanzi[1], Chiara D'Errico[1], Giacomo Roati[1], Matteo Zaccanti[1,2], Michele Modugno[1,3], Massimo Inguscio[1], and Giovanni Modugno[1] — [1]LENS and Università di Firenze, and CNR-INO, Italy — [2]Institut für Quantenoptik und Quanteninformation, Innsbruck, Austria — [3]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain

We study the transport dynamics of matter-waves in the presence of disorder and non-linearity. A Bose-Einstein Condensate of 39K atoms is let free to expand in a quasiperiodic lattice realized by superimposing two laser beams of incommensurate wavelength in standing wave configuration. By means of a broad magnetic Feshbach resonance it is possible to tune the scattering length between atoms at will. In the noninteracting case this system is an experimental realization of the Aubry-André model: if the disorder is strong enough, the system is localized and no expansion is permitted (Anderson localization).

The presence of a weak repulsive interaction allows the coupling between orthogonal localized single particle states and destroys localization. In this case we observe a change of shape of the atomic cloud during the expansion and a slow increase of the width σ of the sample that follows a subdiffusive law: $\sigma(t) \propto t^{\alpha}$, with $\alpha = 0.2 - 0.4$. We find that the exponent increases with the initial interaction energy and the localization length.

Q 40.4 Wed 17:15 HSZ 02

Coherent transport of a BEC in the presence of disorder and nonlinearity — •Tobias Geiger, Thomas Wellens, and Andreas Buchleitner — Physikalisches Institut der Universitaet Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

For a dilute cloud of weakly interacting ultracold bosons subject to a random disorder potential, the Gross-Pitaevskii equation, in its limits, produces reliable results. However, for increasing amounts of disorder and interaction, the stationary solution of the mean field description [1] – and eventually also the mean field description itself – breaks down.

In our approach, we treat the full bosonic N-body problem microscopically in a nonlinear scattering setup. By employing a diagrammatic technique relying on the assumption of a weakly scattering disorder potential [2], one is in principle able to sum up all different orders of the nonlinear scattering series.

Here, we present first preliminary results of different scattering orders and compare them to findings predicted by the Gross-Pitaevskii equation.

[1] T. Paul, M. Albert, P. Schlagheck, P. Leboeuf, and N. Pavloff, Phys. Rev. A **80**, 033615 (2009)
[2] T. Wellens and B. Grémaud, Phys. Rev. A **80**, 063827 (2009)

Q 40.5 Wed 17:30 HSZ 02

Interaction-based reduction of weak localization in coherent transport of Bose Einstein Condensates — •Josef Michl[1], Timo Hartmann[1], Juan Diego Urbina[1], Cyril Petitjean[2], Thomas Wellens[3], Peter Schlagheck[4], and Klaus Richter[1] — [1]Institute of Theoretical Physics, University of Regensburg, Germany — [2]SPSMS-INAC-CEA, Grenoble, France — [3]Physics Department, University of Fribourg, Switzerland — [4]Physics Department, University of Liège, Belgium

Based on the Gross-Pitaevskii-equation, we investigate reflection amplitudes and reflection probabilities in the transport of coherent bosonic matter waves through a fully-chaotic two-dimensional billiard-system. Like in the case of electronic transport, one can observe the effect of weak-localization in this setting. Our interest lies now in the influence of a weak interaction between particles on the weak-localization-peak and its behaviour in the presence of a weak magnetic field in the billiard.

Numerical results on this topic predict a reduction of the weak-localization-peak for small magnetic fields and a vanishing influence of the interaction with an increasing one. Trying to explain that, an analytical technique based on a semiclassical treatment in form of a diagrammatic perturbation theory in the parameter representing the interaction will be presented. Its results are compared to the numerical findings.

Q 40.6 Wed 17:45 HSZ 02

Anderson orthogonality catastrophe in ultracold quantum gases — •Daniel Kotik[1], Martina Hentschel[1], and Walter Strunz[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 83, 01187 Dresden — [2]Institut für Theoretische Physik, TU Dresden, 01062 Dresden

Ultracold quantum gases have attracted a lot of attention in recent years, not least due to their exquisite experimental control and the resulting versatile possibilities to manipulate them.

Here, we study impurity potentials in ultracold bosonic quantum gases and specifically in their Bose-Einstein condensed phase, that result, e.g., from unavoidable defects contained in the material or from deliberately placed perturbations. Our emphasis will be on spatio-temporal perturbations that are suddenly switched-on and spatially localized, as can be realized by switching on an additional laser beam. The many-body response of the quantum gas to this impurity potential is studied numerically and analytically.

We will pay particular attention to the consideration of the bosonic analogue known from solid state theory as Anderson orthogonality catastrophe.