Q 22: Quantum Gases: Bosons III

Time: Tuesday 11:00–13:00 Location: P 204

Q 22.1 Tue 11:00 P 204

Laughlin-like states in bosonic and fermionic synthetic ladders — •Marcello Calvanese Strinati — NEST, Scuola Normale Superiore and Istituto Nanoscienze-CNR, I-56126 Pisa, Italy

We present a numerical study of one-dimensional Laughlin-like states in bosonic and fermionic ladders, which can be realized in one-dimensional gases with synthetic dimension. Similar to two-dimensional genuine Laughlin states, our system exhibits counter-propagating fractional modes. Laughlin-like states in our systems are identified by specific signatures in the chiral current and entanglement properties. We corroborate our numerical results with an analytical analysis based on bosonization techniques.

Q 22.2 Tue 11:15 P 204

Symmetry-broken states strongly interacting flux-ladders — •Sebastian Greschner[1], Marie Piraud[2], Fabian Heidrich-Meisner[2], Ian McCulloch[3], Uli Schollwöck[2], and Temo Vekua[4] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover — [2]Department of Physics and Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München — [3]University of Queensland, Australia — [4]James Franck Institute, The University of Chicago, USA

We study the phase diagram of bosonic and fermionic quantum gases in synthetic dimensional flux-ladders in the limit of strong contact interactions. We characterize the panoply of symmetry broken phases including vortex-lattice and biased ladder phases as well as emerging charge-density wave phases at fractional filling or supersolids.

Q 22.3 Tue 11:30 P 204

Quantum Butterfly Effect for Cold Atoms in Optical Lattices: A Trajectory-Based Derivation in Many-Body Space — •Josef Michl, Juan-Diego Urbina, and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg, Germany

Recently, it was suggested that $\langle[\hat{V},\hat{W}(t)]^\dagger[\hat{V},\hat{W}(t)]\rangle$, is a suitable measure for quantum chaos and the so-called quantum butterfly effect[1], in the sense that the different ordering of the arbitrary operators $\hat{V}$ and $\hat{W}$ with respect to the time evolution operators is sensitive to the hyperbolicity of the underlying classical system. Simple arguments involving Poisson brackets indeed indicate this average to have terms of exponential increase with a rate related to the classical Lyapunov exponent. This behaviour is expected to hold up to time scales of the classical-to-quantum-crossover, known as Ehrenfest or scrambling time. While numerical studies support this claim, analytical explanations are rare and concentrate more on the exponential behaviour and not on the relation between its rate and the Lyapunov exponent. In this presentation we want to fill this gap using semiclassical methods based on the Van-Vleck-propagator for Bose-Hubbard systems, as the picture of interfering classical mean-field trajectories is well suited to provide a quantitative picture in interacting systems. We explicitly discuss the emergence of the Lyapunov exponent and the involved timescales for the simplified picture of the average of the commutator $\langle[\hat{V},\hat{W}(t)]\rangle$.

[1] J. Maldacena, S. H. Shenker & D. Stanford, J. High Energ. Phys., 2016:106

Q 22.4 Tue 11:45 P 204

Are strategies in physics discrete? A remote controlled investigation — •Robert Heck[1], J. Zoller[2], J. J. W. H. Sørensen[1], O. Vuculescu[1], M. G. Andreasen[1], M. G. Bason[3], P. Ejlertsen[1], O. Elíasson[1], J. S. Laustsen[1], L. L. Nielsen[1], R. Müller[1], M. Napolitano[1], A. R. Thorsen[1], C. Bergenholtz[1], J. Arlt[1], T. Calarco[2], S. Montangero[2], and J. F. Sherson[1] — [1]Aarhus University, Denmark — [2]IQST Ulm, Universität Ulm, Germany — [3]School of Physics and Astronomy, University of Nottingham, United Kingdom

There exist multiple distinct strategies for the experimental creation of Bose-Einstein Condensates (BEC) of atoms. Besides in purely magnetic traps, BECs can be created in purely optical dipole traps, or by using a hybrid approach of both. We investigate the complex control landscape that arises when these well-known strategies are combined arbitrarily. This addresses the fundamental question if these strategies are unique or if a continuum of good production strategies exists. We find that although each conventional strategy is locally optimal with respect to changes of individual experimental parameters, bridges between the approaches can be identified by appropriate mixing of variables. In a novel approach, the problem was turned into a computer game and citizen scientists from all over the world could contribute in real-time to the optimization of the experiment. The research findings not only yield optimized experimental sequences, but also give insight into cooperative human solving strategies, which could be adapted in advanced computer-based optimization algorithms in the future.

Q 22.5 Tue 12:00 P 204

Losing coherence by a local disturber: ultra-cold bosons scattering in three dimensions — •Valentin Bolsinger[1,2], Sven Krönke[1,2], and Peter Schmelcher[1,2] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]The Hamburg Center for Ultrafast Imaging, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

We analyze the dynamics of a few interacting, ultra-cold bosons, initially displaced in the longitudinal direction of an anisotropic harmonic trap, scattering with a local disturber. We are interested in the crossover from three towards one dimension and show how both particle correlations and dimensional coupling modify the coherence of the system as well as alter the decay of the center of mass oscillation. In doing so, the many-particle Schrödinger equation is solved by the recently optimized, ab-initio Multi-Layer Multi-Configurational Time-Dependent Hartee method for Bosons (ML-MCTDHB) for three dimensions.

Q 22.6 Tue 12:15 P 204

Periodic Quantum Rabi Model with Ultracold Rubidium Atoms — •Johannes Koch[1], Till Ockenfels[1], Martin Leder[1], Simone Felicetti[2], Enrique Rico[3,4], Carlos Sabin[5], Enrique Solano[3,4], and Martin Weitz[1] — [1]Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, D-53115 Bonn, Germany — [2]Laboratoire Matériaux et Phénomènes Quantiques, Sorbonne Paris Cité, Université Paris Diderot, CNRS UMR 7162, 75013, Paris, France — [3]Department of Physical Chemistry, University of the Basque Country UPV/EHU, Apartado 644, E-48080 Bilbao, Spain — [4]IKERBASQUE, Basque Foundation for Science, Maria Diaz de Haro 3, E-48013 Bilbao, Spain — [5]Instituto de Física Fundamental, CSIC, Serrano 113-bis, E-28006 Madrid, Spain

The quantum Rabi model describing the interaction between a two-level quantum system and a single bosonic mode has been thoroughly studied in the moderate and strong coupling regimes. Here we investigate the model in the deep strong coupling regime, which is inaccessible to experiments using natural light-matter interactions. Our experimental implementation to simulate the quantum Rabi model uses ultracold rubidium atoms in a tailored optical lattice potential, with the two-level system being represented by the occupation of Bloch bands of the lattice. This effective qubit interacts with a quantum harmonic oscillator provided by the atoms being trapped in an optical dipole potential. The present status of the experiment will be presented.

Q 22.7 Tue 12:30 P 204

Measuring finite-range phase coherence in an optical lattice using Talbot interferometry — •Christian Baals[1,2], Bodhaditya Santra[1,4], Ralf Labouvie[1,2], Aranya B. Bhattacherjee[3], Axel Pelster[1], and Herwig Ott[1] — [1]Department of Physics and Research Center OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Staudinger Weg 9, 55128 Mainz, Germany — [3]School of Physical Sciences, Jawaharlal Nehru University, New Delhi-110067, India — [4]Zentrum für optische Quantentechnologien, Universität Hamburg, 22761 Hamburg, Germany

The temporal Talbot effect is exploited in our experiment to measure finite-range first-order correlations of a matter-wave field. The working principle relies on the fast blanking of the lattice potential: Upon switching off, the wave-packets at each lattice site expand and interfere with each other. After a variable time, the lattice potential is switched on again resulting in a projection of the time-evolved wavefunction onto the potential landscape of the lattice. The additional energy brought into the system becomes observable in an increase of temperature or excitation of atoms into higher energy bands. At integer multiples of the Talbot time, the atomic density distribution shows revivals, where the emerging contrast depends on the phase coherence between the interfering wave packets. Thereby, later revivals correspond to the interference of matter waves from more distant lattice sites. We apply this interferometer to study the build-up of phase coherence after a quantum quench [arXiv:1611.08430].

Q 22.8 Tue 12:45 P 204

Probing the molecular product-state distribution after neutral three-body recombination — •Markus Deiss[1], Joschka Wolf[1], Artjom Krükow[1], Amir Mohammadi[1], Amir Mahdian[1], Eberhard Tiemann[2], and Johannes Hecker Denschlag[1] — [1]Institut für Quantenmaterie, Universität Ulm, 89069 Ulm, Germany — [2]Institut für Quantenoptik, Leibniz Universität Hannover, 30167 Hannover, Germany

The process of three-body recombination, where two atoms form a molecule and a third atom carries away part of the released binding energy, is still hardly understood. In particular, the population distribution of molecular product states is a subject under discussion for lack of experimental data and since the theoretical description is difficult. Here we present first measurements of the product-state distribution of diatomic molecules after three-body recombination for the regime of lowest binding energies. From our spectra, we extract the dependence of the population distribution on the vibrational and rotational excitation, providing important information to test and develop model calculations.