DY 35: ISS Transport and Localization of interacting Bosons II

Time: Thursday 14:30–16:00 Location: BAR Schön

DY 35.1 Thu 14:30 BAR Schön

Interband dynamics in a many-body Wannier-Stark system

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In the last years the dynamics of ultracold atoms, in particular Bose condensates loaded into optical lattices, have become amply studied in view of interesting phenomena like Landau-Zener tunnelling, resonantly enhanced tunnelling (RET) and Bloch oscillations. Regular and chaotic regimes can be reached by varying the parameters in the many-body description of ultracold bosons [1]. We present results obtained by studying the dynamical properties of a two-band Bose-Hubbard Hamiltonian for a one-dimensional tilted optical lattice [2]. We compare the interband dynamics for the single particle limit and for the fully interacting system, by computing the average occupation of the upper band. The spectral properties (avoided crossings) provide a comprehensive understanding of the dynamics close to RET as a control parameter is varied and the number of particles is increased. The dynamical correlations between the bands imply interesting perspectives for state-of-the-art experiments with ultracold bosons.

[1] A. Tomadin, R. Mannella, and S. Wimberger, Phys. Rev. Lett. 98, 130402 (2007). [2] P. Ploetz, J. Madroñero, and S. Wimberger, J. Phys. B 43, 081001(FTC) (2010).

DY 35.2 Thu 14:45 BAR Schön

Stability and decay of Bloch oscillations in Bose-Einstein condensates with time-dependent atom-atom interactions

— •Christopher Gaul[1], Elena Díaz[1,2], Cord A. Müller[3], Rodrigo Lima[4], and Francisco Domínguez-Adame[1] — [1]GISC, Departamento de Física de Materiales, Universidad Complutense, E-28040 Madrid, Spain — [2]Institute for Materials Science, Technische Universität Dresden, D-01062 Dresden, Germany — [3]Centre for Quantum Technologies, National University of Singapore, Singapore 117543, Singapore — [4]Instituto de Física, Universidade Federal de Alagoas, Maceió AL 57072-970, Brazil

Bose-Einstein condensates in tilted optical lattices allow the observation of Bloch oscillations (BOs). Generically, the interaction leads to dephasing and to the decay of the wave packet. By means of Feshbach resonances, however, experimentalists can tune the s-wave scattering length to zero or modulate it in time. We investigate the effect of such time-managed interactions on BOs. Additionally to the noninteracting case and a solitonic solution, we find an infinite family of modulations that preserve the Bloch oscillating wave packet [1]. In these cases, the stability follows from a time-reversal argument. In the unstable cases, we employ a collective-coordinates ansatz and a stability analysis, in order to quantify the decay of the BOs. In particular we show that in presence of external perturbations, an additional modulation of the interaction can enhance the lifetime of the Bloch oscillation [2].

[1] Gaul et al. PRL 102, 255303 (2009)
[2] Díaz et al. PRA 81, 051607R (2010)

DY 35.3 Thu 15:00 BAR Schön

Wave packet surgery in driven optical lattices

— •Stephan Arlinghaus and Martin Holthaus — Institut für Physik, Carl von Ossietzky Universität, D-26111 Oldenburg

The dynamics of particles in a periodic potential under the influence of homogeneous external forcing is governed by Bloch's acceleration theorem, provided the single-band approximation remains viable. However, interband transitions induced by strong time-periodic forces, which lie ouside the scope of this old approach, offer most interesting perspectives for coherent control. We show how a generalized acceleration theorem, based on the use of Floquet states, leads to novel control strategies, allowing one to selectively "cut out" certain parts from the particles' wave packets. Ultracold atoms in driven optical lattices provide experimentally accessible testing ground for these ideas.

DY 35.4 Thu 15:15 BAR Schön

Weak (anti-)localization of Bose-Einstein condensates in two-dimensional chaotic cavities: numerical results

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The possibility to induce artificial magnetic gauge potentials for matter waves [1] and to create almost arbitrarily shaped confinement potentials [2] makes it now interesting and feasible to study coherent transport of Bose-Einstein condensates through various mesoscopic structures. Previous theoretical studies have focused on the question how coherent backscattering in disordered potentials is modified by the presence of the atom-atom interaction [3]. We now study the analogous scenario of weak localisation in ballistic billiard geometries which exhibit chaotic classical dynamics. To this end we numerically investigate the quasi-stationary propagation of a condensate through such structures within the mean-field approximation. The transmission is measured as a function of the magnetic gauge field and of the non-linearity. With increasing non-linearity an inversion of the weak-localisation peak is visible and its origin will be discussed.

[1] Y.-J. Lin et al., Phys. Rev. Lett. **102** 130401 (2009)
[2] K. Henderson et al., New J. Phys. **11**, 043030(2009)
[3] M. Hartung et al., Phys. Rev. Lett. **101**, 020603 (2008).

DY 35.5 Thu 15:30 BAR Schön

Destruction of localization in a nonlinear generalization of the quantum kicked rotor

— •Goran Gligorić, Joshua Bodyfelt, and Sergej Flach — MPI für Physik komplexer Systeme

Quantum suppression of classically chaotic diffusion was first observed numerically in the quantum kicked rotor model. This phenomenon can be considered in many aspects as the dynamical version of Anderson localization in tight-binding disordered models [1]. In the case of the kicked rotor there is no true randomness and diffusion after an initial time interval appears, resulting from chaotic dynamics in the corresponding classical counterpart. The realization of Bose-Einstein condensates has opened a new opportunity for studying dynamical systems in the presence of many-body interactions. In the mean field approximation, these interactions can be represented by adding a quartic nonlinearity in the Schrödinger equation. Our aim is to utilize such a model, as introduced by Shepelyansky [2] in order to understand how nonlinearity generally affects the kicked rotor model. Particularly, we aim to understand the influence of nonlinearity on dynamical localization; of special concern is the possibility of a critical nonlinear strength above which localization is destroyed, and how this destruction comes about. Lastly, we will consider the corresponding anomalous subdiffusion law in this regime and test its universality.

[1] S. Fishman, D.R. Grempel and R.E. Prange, Phys. Rev. A 29 (1984) 1639
[2] D.L. Shepelyansky, Phys. Rev. Lett. 70 (1993) 1787

DY 35.6 Thu 15:45 BAR Schön

Localization of two interacting bosons in a random potential

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We study the dynamics of two interacting bosons in one-dimensional random lattices using the Bose-Hubbard model. In the absence of interaction all eigenstates are spatially localized and both particles follow the single particle dynamics corresponding to Anderson localization. Our study aims to clarify the interplay of disorder and interactions in few-body dynamics. In particular, we calculate the enhancement factor of the localization length l_2 in comparison to the single particle localization length l_1 for weak disorder performing rigorous numerical calculations. Previous studies based on the mapping of the two-particle problem onto a physically relevant matrix model contained different statements on this issue [1]. Our findings are in tact with predictions, which follow from the statistical properties of the overlap integrals of single particle eigenvectors [2].

[1] D.L. Shepelyansky, Phys. Rev. Lett. 73, 2607 (1994); K. Frahm, A. Müller-Groeling, J.-L. Pichard, D. Weinmann, Europhys. Lett., 31, 169 (1995)
[2] D.O. Krimer, S. Flach, Phys. Rev. E 82, 046221 (2010)