Q 32: Ultra-cold atoms, ions and BEC I

Time: Tuesday 14:00–16:00 Location: V7.02

Invited Talk Q 32.1 Tue 14:00 V7.02

Macroscopic Quantum Tunneling of Solitons in Bose-Einstein Condensates — •Lincoln D. Carr[1,2] and Joseph A. Glick[2,3] — [1]Physikalisches Institut, Universität Heidelberg, Germany — [2]Department of Physics, Colorado School of Mines, U.S.A — [3]Department of Physics and Astronomy, Michigan State University, U.S.A.

We study the quantum tunneling dynamics of many-body entangled solitons composed of ultracold bosonic gases in 1D optical lattices. A bright soliton, confined by a potential barrier, is allowed to tunnel out of confinement by reducing the barrier width and for varying strengths of attractive interactions. Simulation of the Bose Hubbard Hamiltonian is performed with time-evolving block decimation. We find the characteristic 1/e time for the escape of the soliton, substantially different from the mean field prediction, and address how many-body effects like quantum fluctuations, entanglement, and nonlocal correlations affect macroscopic quantum tunneling; number fluctuations and second order correlations are suggested as experimental signatures. We find that while the escape time scales exponentially in the interactions, the time at which both the von Neumann entanglement entropy and the slope of number fluctuations is maximized scale only linearly.

Q 32.2 Tue 14:30 V7.02

Confinement-Induced collapse of a dipolar Bose-Einstein Condensate in an optical lattice — •Emanuel Henn[1], Juliette Billy[1], Stefan Müller[1], Holger Kadau[1], Thomas Maier[1], Mathias Schmitt[1], Mattia Jona-Lasinio[2], Luis Santos[2], Axel Griesmaier[1], and Tilman Pfau[1] — [1]5.Physikalisches Institut, Universitat Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Institut fur Theoretische Physik, Leibniz Universitat Hannover, 30167 Hannover, Germany

We experimentally investigate the collapse of a dipolar Bose-Einstein Condensate (dBEC) in a 1D lattice. In contrast with the standard method of changing the contact interaction energy, the collapse is here induced by a sudden change in the confining potential. Only a dBEC offers this possibility since its stability threshold strongly depends on the lattice depth due to the anisotropic character of the dipolar interaction [1]. For shallow lattices, in the extreme case where the trapping potential is completely switched off, the dBEC collapses during the free expansion, which is also a unique feature of dipolar systems. For deep lattices, structured ground-states are expected to appear. However, strong atom losses and dephasing effects restrict the experimental parameter range. We present here our methods to overcome these limitations and discuss preliminary results.

[1] S. Müller et al., Phys. Rev. A 84, 053601 (2011)

Q 32.3 Tue 14:45 V7.02

Quantum stochastic description of collisions in a canonical Bose gas — •Patrick Navez[1] and Achilleas Lazarides[2] — [1]Institut für Theoretische Physik, TU Dresden, 01062 Dresden, Germany — [2]Max Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany

We derive a stochastic process that describes the kinetics of a one-dimensional Bose gas in a regime where three body collisions are important. In this situation the system becomes non integrable offering the possibility to investigate dissipative phenomena more simply compared to higher dimensional gases. Unlike the quantum Boltzmann equation describing the average momentum distribution, the stochastic approach allows a description of higher-order correlation functions in a canonical ensemble. As will be shown, this ensemble differs drastically from the grand canonical one. We illustrate the use of this method by determining the time evolution of the momentum mode particle number distribution and the static structure factor during the evaporative cooling process.

Q 32.4 Tue 15:00 V7.02

Quasi-Particle Theory for Strongly Interacting Lattice Bosons — •Ulf Bissbort, Michael Buchhold, and Walter Hofstetter — Institut für Theoretische Physik, Goethe Universität Frankfurt a.M.

We develop a systematic quasi-particle theory for interacting bosons in optical lattices, which does not rely on a large condensate fraction and is valid for arbitrary interaction strengths. It is based upon the diagonalization of fluctuation operators on top of the bosonic Gutzwiller ground state and in the classical limit equivalent to the linearization of the time-dependent Gutzwiller equations of motion. The various collective modes, such as the sound and amplitude mode in the condensate, or the particle and hole mode in the Mott insulator emerge naturally from this unified formalism. It is valid beyond the realm of the latter, also being able to describe dynamics in the Mott insulator. For states in the vicinity of the respective Gutzwiller ground state, the system can be described as an ensemble of non-interacting quasi-particles, allowing for a direct treatment of time-dependent phenomena. Specifically, we calculate spectral functions and the dynamic structure factor for homogeneous systems in both the Mott insulator and condensate. The decay processes of the various quasi-particle modes induced by the higher order terms neglected in the quasi-particle Hamiltonian are identified, and the lifetimes are calculated. Furthermore we apply our theory to study quantum quenches and subsequent relaxation processes.

Q 32.5 Tue 15:15 V7.02

Breathing oscillations of a trapped impurity in a Bose gas — •Martin Bruderer[1], Tomi Johnson[2], and Dieter Jaksch[2] — [1]Universität Konstanz — [2]University of Oxford

Motivated by a recent experiment of Catani et al. [1] we study breathing oscillations in the width of a harmonically trapped impurity interacting with a separately trapped Bose gas. We provide an intuitive physical picture of such dynamics at zero temperature, using a time-dependent variational approach. In the Gross-Pitaevskii regime we obtain breathing oscillations whose amplitudes are suppressed by self-trapping due to interactions with the Bose gas. Introducing phonons in the Bose gas leads to the damping of breathing oscillations and non-Markovian dynamics of the width of the impurity. Our results reproduce the main features of the impurity dynamics observed by Catani et al. [1] despite experimental thermal effects, and are supported by simulations of the system in the Gross-Pitaevskii regime.

[1] J. Catani et al., Quantum dynamics of impurities in a 1D Bose gas, arXiv:1106.0828v1 preprint (2011)

Q 32.6 Tue 15:30 V7.02

A novel route to BEC of calcium — •Purbasha Halder, Chih-Yun Yang, and Andreas Hemmerich — Institut für Laserphysik, Universität Hamburg

We present a novel scheme for obtaining a condensate of alkaline-earth-metal and rare earth elements, and demonstrate it successfully for ^{40}Ca atoms. This all-optical method avoids complications of narrow-line laser cooling and trapping schemes which form the basis of previous experimental approaches. By this method, we efficiently load a cold and dense sample of atoms into a dipole trap directly from a MOT operating on the metastable $^{3}P_{2}$ state. Loading is carried out by selectively depumping only those MOT atoms which are near the minimum of the dipole trap potential. This increases the phase space density by four orders of magnitude. Further cooling to quantum degeneracy is achieved by forced evaporation, yielding a condensate containing 6000 atoms.

Q 32.7 Tue 15:45 V7.02

Ansatz for bosons in harmonic trap: from two to many — •Ioannis Brouzos and Peter Schmelcher — Zentrum für optischen Quantentechnolgien, Hamburg Germany

We develop an analytical many-body wave function to accurately describe the crossover of a one-dimensional bosonic system from weak to strong interactions in a harmonic trap. The explicit wave function, which is based on the exact two-body states, consists of symmetric multiple products of the corresponding parabolic cylinder functions, and respects the analytically known limits of zero and infinite repulsion for arbitrary number of particles. For intermediate interaction strengths we demonstrate, that the energies, as well as the reduced densities of first and second order, are in excellent agreement with large scale numerical calculations.