Q 39: Quantengase: Wechselwirkungseffekte 2

Time: Thursday 10:30–12:00 Location: V7.01

Group Report Q 39.1 Thu 10:30 V7.01

Variational and full-numerical investigation of the dipolar time-dependent Gross-Pitaevskii equation — •Rüdiger Eichler, Robin Gutöhrlein, Patrick Köberle, Manuel Kreibich, Jörg Main, Günter Wunner, and Damir Zajec — 1. Institut für Theoretische Physik, Universität Stuttgart

The dynamics of dipolar Bose-Einstein condensates can be described in the mean-field limit by an extended time-dependent Gross-Pitaevskii equation.

Due to the non-local and non-linear character of the GPE for these condensates a variety of new effects occurs. We show that the wave function describing the ground state may degenerate which leads to bifurcations and exceptional points. Furthermore, we calculate Bogoliubov spectra and investigate the dynamics close to the ground state as well as beyond this linear regime. Our calculations are capable of describing the angular collapse, soliton ground states, soliton collisions, and additional effects.

Since the numerical solution of the three-dimensional GPE on a grid is a challenging task, the code has been implemented in CUDA to be run massively parallel on graphics cards. As a full-fledged alternative we use the time-dependent variational principle to obtain equations of motion for the parameters of the parametrized wave function. We show that both methods are of value in that their results support each other mutually.

Q 39.2 Thu 11:00 V7.01

Macroscopic quantum tunneling in Bose-Einstein condensates with long range 1/r-interaction — •Matin Kaufmann, Jörg Main, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart

The decay of Bose-Einstein condensates via macroscopic quantum tunneling is investigated in the case of spherical symmetry at zero temperature with the bounce trajectory formalism. The Gross-Pitaevskii equation is solved with a variational ansatz. To calculate the tunneling rate we must account for the fluctuations of the wave function and consider the stability of the bounce trajectory. Therefore we solve the Bogoliubov-de Gennes equations both for stationary wave functions and the bounce trajectory in imaginary time. Using an appropriate basis of fluctuations this method allows time efficient calculations of well converged Bogoliubov-de Gennes eigenvalues. This approach, however, is not restricted to wave functions obtained in a variational approximation and can be extended to full numerical grid computations.

Q 39.3 Thu 11:15 V7.01

Microscopic Scattering Theory for Interacting Bosons in a Random Potential — •Tobias Geiger, Thomas Wellens, and Andreas Buchleitner — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

We microscopically derive a theory for scattering of N atoms – with all atoms initially prepared in the same single-particle momentum eigenstate – from a three dimensional random disorder potential in the presence of two-body interactions. Starting from an exact diagrammatic expansion of the N-particle scattering amplitude, we identify those combinations of diagrams which – in the case of a weak random potential (mean free path much larger than wavelength) – survive the disorder average, and sum up the remaining ladder and crossed diagrams non-perturbatively in the strength of the particle-particle interaction [1]. We show that the latter leads to a relaxation of the individual particles' energies towards a Maxwell-Boltzmann distribution as the particles diffuse throughout the random potential. As interferential correction to diffusive transport, we furthermore consider coherent backscattering and analyze how this coherent effect is modified by interactions.

[1] T. Wellens and B. Grémaud, Phys. Rev. Lett. **100**, 033902 (2008).

Q 39.4 Thu 11:30 V7.01

Three-body recombination in the unitary Bose gas — •Ulrich Eismann[1], Igor Ferrier-Barbut[1], Andrew Grier[1], Tim Langen[2], Benno Rem[1], Frédéric Chevy[1], and Christophe Salomon[1] — [1]Laboratoire Kastler Brussel, ENS, UPMC, CNRS UMR 8552, 24 rue Lhomond, 75231 Paris, France — [2]Vienna Center for Quantum Science and Technology, Atominstitut, TU Wien, Stadionallee 2, 1020 Vienna, Austria

Three-body recombination is the most fundamental limit of the lifetime of interacting ultra-cold Bose gases. In the low-temperature regime, the interactions between ultra-cold atoms can be described by a single parameter, the s-wave scattering length a. In 1996, an a^4 dependence of the recombination loss rate L_3 was predicted [1]. However, finite temperatures impose a limit on recombination at unitarity, where $|a| \to 0$, such that L_3 does not diverge [2].

We present temperature-dependent measurements of the unitarity-limited, three-body loss rate. Moreover, by employing the method of [3], we measure the equation of state of the finite-temperature unitary Bose gas.

[1] P. O. Fedichev et al., Phys. Rev. Lett. **77**, 2921 (1996)
[2] C. H. Greene et al., Nuclear Physics **A737**, 119 (2004)
[3] S. Nascimbène et al., Nature **463**, 1057 (2010)

Q 39.5 Thu 11:45 V7.01

Regular to chaotic resonant tunneling — •Carlos Parra Murillo[1], Javier Madronero[2], and Sandro Wimberger[1] — [1]Institut für theoretische Physik, Heidelberg Universität, D-69120, Heidelberg — [2]Physik Department, Technische Universität München, D-85747 Garching

The transport properties of flat optical lattices loaded with ultracold atoms have been amply studied in recent years in theory as well as in experiment. The introduction of a Stark force as a control parameter allows one the realization of resonant tunneling between energy levels in different potential wells. An example is the control of interband tunneling by the Stark force [1]. The latter effect is strongly modified by the presence of interparticle interaction. In this work we study this Wannier-Stark system based on a two-band Bose-Hubbard model. The spectrum is computed by exact numerical diagonanalization and studied as a function of the filling factor of the lattice, the order of the resonance and the potential parameters. The dynamical correlations between the bands imply interesting perspectives for the state-of-the-art experiments with ultracold bosons.

[1] Sias, C. Zenesini, A. Lignier, H. Wimberger, S. Ciampini, D. Morsch, O. and Arimondo, E., Phys. Rev. Lett. 98, 120403 (2007)