Q 37: Quantengase (Wechselwirkungseffekte I)

Zeit: Donnerstag 11:00–13:15 Raum: 1C

Q 37.1 Do 11:00 1C

A number filter for matter-waves — •Reinhold Walser[1], Andreas Sizmann[2], Gerrit Nandi[1], and József Fortágh[3] — [1]Institut für Quantenphysik, Universität Ulm — [2]Ludwig-Maximilians-Universität München — [3]Physikalisches Institut der Universität Tübingen

In current Bose-Einstein condensate experiments, the shot-to-shot variation of atom number fluctuates up to 10%. In here, we present a procedure to suppress such fluctuations by using a nonlinear $p-\bar{p}$ matter wave interferometer for a Bose-Einstein condensate with two internal states and a high beam-splitter asymmetry ($p, \bar{p} \neq 0.5$). We analyze the situation for an inhomogeneous trap within the Gross-Pitaevskii mean-field theory, as well as a quantum mechanical Josephson model, which addresses complementary aspects of the problem and agrees well otherwise.

[1] M. Kitagawa and M. Ueda, Phys. Rev. A, **47**, 5138 (1993).
[2] S. Schmitt, J. Ficker, M. Wolff, F. König, A. Sizmann and G. Leuchs, Phys Rev. Lett. **81**, 2446 (1998).
[3] A. Sørensen and L.-M. Duan and J. I. Cirac and P. Zoller, Nature, **409**, 63 (2001).
[4] U. V. Poulsen and K. Mølmer, Phys. Rev. A, **65**, 033613, (2002).
[5] G. Nandi, A. Sizmann, J. Fortágh, and R. Walser, arXiv:0710.1737 (2007).

Q 37.2 Do 11:15 1C

Are there semi-fluxons in cold atomic gases? — •Michael Eckart[1], Reinhold Walser[1], Wolfgang P. Schleich[1], Dieter Koelle[2], Reinhold Kleiner[2], and Edward Goldobin[2] — [1]Institut für Quantenphysik, Universität Ulm, 89069 Ulm — [2]Physikalisches Institut-Experimentalphysik II, Universität Tübingen, 72076 Tübingen

Fluxons are single quanta of magnetic flux ($\Phi_0 \approx 2.07 \times 10^{-15}$ Wb) which may exist in superconducting long Josephson junctions [1]. By making a Josephson junction out of two parts with a phase difference of π between the tunneling supercurrents, one can construct a so-called 0-π junction, where the ground state may correspond to a spontaneously created magnetic flux of $\Phi_0/2$ localized at the 0-π boundary. Such semifluxons are intensively investigated in superconducting structures [2-4].

In this contribution we propose a technique to create and study similar 0-π junctions in cold atomic gases [5,6]. We investigate the interaction of single atoms as well as BECs with laser light to gain insight into the fundamental physics that eventually also sheds light on the macroscopic behavior of the semifluxons in superconductors.

[1] W. Buckel and R. Kleiner, *Superconductivity: Fundamentals and applications*, Wiley-VCH, Berlin (2004)
[2] E. Goldobin et al., *Phys. Rev. B* **72**, 054527 (2005)
[3] K. Buckenmaier et al., *Phys. Rev. Lett.* **98**, 117006 (2007)
[4] H. Hilgenkamp et al., *Nature* **422**, 50 (2003)
[5] V.M. Kaurov and A.B. Kuklov, *Phys. Rev. A* **73**, 013627 (2006)
[6] E. Goldobin et al., *New J. Phys.*, in preparation

Q 37.3 Do 11:30 1C

Atom-molecule oscillations in a Mott insulator — •Matthias Lettner, Niels Syassen, Dominik M. Bauer, Daniel Dietze, Thomas Volz, Stephan Dürr, and Gerhard Rempe — Max Planck Institut für Quantenoptik, Hans-Kopfermann-Str. 1, D-85748 Garching, Germany

Near a Feshbach resonance an unbound state of two ultracold atoms is coherently coupled to a molecular one. This realizes a coupled two level system. We report on the observation of large-amplitude oscillations. The damping is so weak that 29 cycles are observed. The experiment uses ^{87}Rb in an optical lattice and a Feshbach resonance near 414 G. The frequency and amplitude of the oscillations depend on the magnetic field in a way that is well described by a two-level model. Also the observed density dependence of the oscillation frequency agrees with the theoretical expectation. We confirmed that the state produced after a half-cycle contains exactly one molecule at each lattice site. In addition, we show that for energies in a gap of the lattice band structure, the molecules cannot dissociate.

[1] N.Syassen *PRL* 99, 033201 (2007).

Q 37.4 Do 11:45 1C

Coherent backscattering of Bose-Einstein condensates in two dimensional disorder potentials — •Michael Hartung, Klaus Richter, and Peter Schlagheck — Institute for Theoretical Physics, University of Regensburg, Germany

The rapid progress in the experimental techniques for Bose-Einstein condensates permits detailed studies of mesoscopic transport dynamics of interacting matter waves with rather high accuracy and high flexibility in the control of parameters. We particularly focus on quasi-stationary transport processes of Bose-Einstein condensates through two dimensional disorder potentials by integrating the time-dependent Gross-Pitaevskii equation.

In the limit of vanishing atom-atom interaction we observe coherent backscattering, which leads to a sharp cone, centered around the backward direction, in the angle resolved density of the scattered condensate. This is a characteristic signature of weak localization and arises due to the constructive interference of semiclassical scattering paths with their time reversed counterparts. This coherent backscattering peak is transformed into a pronounced dip for weak repulsive interaction, and eventually vanishes for strong interaction. In this latter regime we find intrinsic time-dependent behavior of the condensate wavefunction, which effectively suppresses the interference phenomena that give rise to the coherent backscattering signal.

Q 37.5 Do 12:00 1C

Bifurcations in Bose-Einstein condensates with dipolar interactions — •Patrick Wagner, Jörg Main, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart, 70550 Stuttgart

We study Bose-Einstein condensates with dipolar and contact interaction within Gross-Pitaevskii theory. As an interesting novel phenomenon we find two ground-state solutions for negative as well as for positive scattering lengths. Below a critical value of the scattering length, no solution exists. We also discuss the dependence of physical properties of the condensate on the trap frequencies.

Q 37.6 Do 12:15 1C

Linear stability of Bose-Einstein condensates with attractive $1/r$-interaction — •Jörg Main, Holger Cartarius, Tomaž Fabčič, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart, 70550 Stuttgart

We investigate the stability of the two nodeless stationary solutions, which are created in a tangent bifurcation in the Gross-Pitaevskii equation for condensates with attractive $1/r$-interaction. Using the Fréchet derivative of the time-dependent nonlinear integro-differential equation, we calculate the eigenvalues of the linearized system. The two stationary solutions are found to be an elliptic and a hyperbolic fixed point. The numerically exact solutions are compared with the results of an approximative variational approach, which leads to analytic expressions for the eigenmodes of the linearized time-dependent equation. There are quantitative differences between both approaches, however, qualitatively they agree very well.

Q 37.7 Do 12:30 1C

Dynamics of Bose-Einstein condensates with inter-particle interaction — •Tomaž Fabčič, Jörg Main, Holger Cartarius, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart, 70550 Stuttgart

The time-dependent extended Gross-Pitaevskii equation for Bose-Einstein condensates with attractive inter-atomic interaction is investigated. The two stationary solutions created in a tangent bifurcation are shown to be elliptic and hyperbolic, respectively. The stable stationary state is surrounded by solutions periodically oscillating in time whereas wave functions in the unstable region undergo a collapse within finite time. Below the tangent bifurcation no stationary solutions exist, i.e., the condensate is always unstable and collapsing. Computations are presented for atomic $1/r$ as well as dipolar interactions.

Q 37.8 Do 12:45 1C

Discovery of exceptional points in stationary states of Bose-Einstein condensates — •Holger Cartarius, Jörg Main, and Günter Wunner — 1. Institut für Theoretische Physik, Universität

Stuttgart, 70550 Stuttgart

The stationary Gross-Pitaevskii equation exhibits a nodeless solution which is born together with the ground state in a tangent bifurcation. The phenomenon has been demonstrated for condensat es in a harmonic trap and, recently, has also been found for condensates with attractive $1/r$-interaction and condensates with dipole-dipole interaction. At the bifurcation point both states coalesce, i.e. the energies and the wave functions are identical, a situation known from exceptional points in linear non-Hermitian Hamiltonians. We point out that the mean field energy, the chemical potential, and the wave functions in the cases mentioned above show the same behavior as an exceptional point in a linear quantum system. For the self-trapping case of a condensate with $1/r$-interaction we find analytic expressions directly demonstrating the branch point singularity structure of the states.

Q 37.9 Do 13:00 1C

Dynamics of strongly-correlated bosons in ladder-like optical lattices — •Arturo Argüelles and Luis Santos — Appelstraße 2, 30167 Hannover, Germany

We analyze the physics of strongly-correlated bosons in ladder-like optical lattices out of equlibrium formed by two connected one-dimensional wires. In particular, we investigate Josephson-like oscillations between initially unbalanced wires, and study the effect of the in-wire correlations on the transversal dynamics between the wires. In absence of interactions, the system would perform standard Josephson-like oscillations of the relative population. Due to strong interactions, strong correlations lead to a significant damping of such population oscillations. In our analysis we study by means of matrix-product state techniques the dependence of the damping ratio as a function of the interation regime.