Optimal Quantum Control of Bose-Einstein condensates in magnetic microtraps

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Coherent manipulation of Bose-Einstein-condensates confined in optical dipole traps, atom chips, and radio-frequency potentials have been demonstrated in a series of experiments.

Atom interferometers based on Bose-Einstein-condensates usually suffer from the nonlinear interactions, originating from atom-atom scatterings, which leads to phase diffusion in the split condensate. A possible way out is to seek for narrow number distributions of the split condensate, i.e., squeezed states.

In the first part of the talk we will focus on optimal control of the transport and splitting of the condensates within the Gross-Pitaevskii equation. Thereby, the confining trap is either displaced or continuously transformed from a single well to a double well. We show that trapping of the condensate in the ground state of the trap at the final time is possible also for short splitting times.

Then we present optimal control results for a generic two-mode model of the splitting process. Here we aim to minimize the number fluctuations between atoms in the left or right well. We show that counter-intuitive splitting protocols allow efficient number squeezing on much shorter time scales compared to adiabatic splitting. An interpretation for the oscillating control can be obtained using a parametric harmonic oscillator model for the system.

We give also an outline of optimal number squeezing within the multi-configurational time dependent Hartree equations for Bosons MCTDHB(2). These equations offer a realistic description of the non-adiabatic splitting process.