Optimizing number squeezing when splitting a mesoscopic condensate

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Confined atom interferometers using Bose-Einstein condensates (BECs) offer new prospects for matter wave interferometry and precision measurements [1]. Coherent manipulation and interference using optical dipole traps, atom chips, and radio-frequency (RF) potentials have been demonstrated in a series of experiments. Number squeezed states [2, 3] enhance the phase sensitivity of atom interferometers and reduce phase diffusion in split Bose-Einstein condensates.

In this paper we show that counter-intuitive splitting protocols allow efficient number squeezing on much shorter time scales [4] compared to quasi-adiabatic splitting. This is achieved by controlling the interplay between tunneling and nonlinear interaction using optimal control theory (OCT) within the Multi-configurational time dependent Hartree equations for Bosons MCTDHB [5]. We are seeking for maximal squeezing, while the condensates should be at rest and decoupled at the end of the splitting.

We find different control scenarios when using different function spaces for the optimization: Either we obtain solutions with oscillating tunnel coupling [4], which are connected to parametric oscillations; alternatively we find a different physical strategy with smoother and less oscillatory solutions, which is related to the general squeezing control strategy proposed by [6].

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