Optimal Control of Bose-Einstein condensates beyond the Gross-Pitaevskii mean field description

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Optimizing number squeezing when splitting a Bose-Einstein condensate requires a description beyond the Gross-Pitaevskii equation, as has been shown in the talk by Hohenester et al.

Here, we will present the multi-configurational time dependent Hartree equations for Bosons MCTDHB(2) in more detail. They consist of a spatial wave function for each of the two condensate orbitals analogous to the Gross-Pitaevskii equation, and a number part, describing the distribution of atoms between the orbitals. Using these equations allows for a control parameter which is related to the confining potential and thus directly accessible in experiments.

When applying optimal control to these equations, we use an efficient numerical scheme based on Crank-Nicholson steps and including Newton iterations. This and other techniques used in the optimization will be presented.

In our optimal control problem we require optimal squeezing within a given time interval, and additionally we want the system to stay in a stationary state after optimization. The resulting control problem of combined squeezing and trapping is quite tricky and requires several subsequent optimization steps.

The results show that squeezing is possible one order of magnitude faster as compared to quasi-adiabatic exponential splitting schemes.

Finally, we show that the states prepared by the optimization are very useful for atom interferometry.