Non-adiabatic quantum state control in few-well few-atom systems

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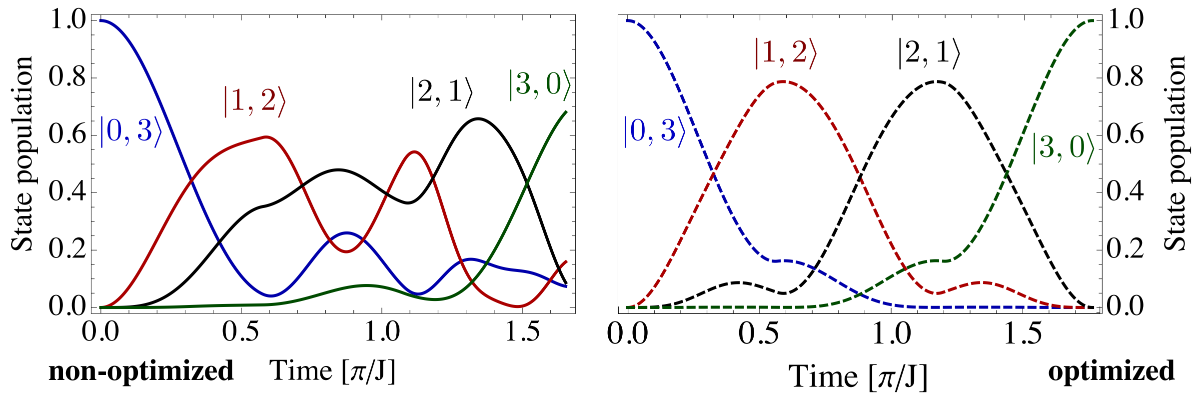
A scheme for arbitrary unitary control of ensembles of interacting bosonic atoms in two-well systems is presented, which uses a discrete sequence of local potential variations as the only control parameter. Exact solutions, readily available for infinite interaction strength, are used as a starting point for numerical optimization of high-fidelity procedures to arbitrarily manipulate quantum states. We thereby combine universal but artificially constrained ``bang-bang'' quantum control with the Euler-decomposition of large unitary matrices to yield a practical powerful scheme. With non-adiabatic population transfer, N00N-state creation, and a transistor-like, conditional evolution of several atoms, we demonstrate the efficiency of our proposal [1].



Non-adiabatic transfer of three particles between two wells, $|0,3\rangle \rightarrow |3,0\rangle$, based on a simple sequence of couplings at avoided level crossings of the interaction Hamiltonian. The time-evolution of the population of the respective Fock-states is shown for the original, non-optimized scheme (left) and for the numerically optimized sequence (right). The original sequence does not yield a satisfactory result, but numerical optimization yields perfect fidelity for the transfer process, while keeping the simple control sequence structure.

References:

[1] Malte C. Tichy, Mads Kock Pedersen, Klaus Mølmer, Jacob F. Sherson, arxiv:1301.2991 (2013).