Optimal control of the quantum state of a Bose Einstein Condensate in an optical lattice

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Abstract

I will present the recent results we obtained on the implementation of optimal control on a Bose-Einstein condensate in a 1D optical lattice [1]. Through the optimization of the time variation of a single parameter (the lattice position) with a simple first-order gradient algorithm, we can reliably prepare arbitrary periodic quantum states in the lattice, on timescales typically shorter than with more standard protocols. We demonstrate the efficient preparation of momentum states superpositions, with precise control of their weights and relative phase. We also prepare specific eigenstates in the band diagram of the lattice potential, or superpositions thereof, with good fidelities. This scheme appears robust to the presence of an external confinement and atomic interactions.

This versatile scheme is relevant for state preparation in quantum simulations. For example, it could be applied to Floquet systems in periodically-modulated optical lattices, and could improve our recent results on the observation of chaos-assisted tunnelling resonances in a semi-classical phase space [2] through the optimal preparation of the initial state. I will present our latest results on the controlled generation of squeezed states of a BEC in phase space. Optimal control could also be used to further engineer Floquet systems, or to enhance sensing capabilities with cold atoms.

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