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Optimal control of Bose-Einstein condensates in an optical lattice

I will present our results on applying quantum optimal control to shape the phase-space distribution of Bose-Einstein condensates in a one-dimensional optical lattice. Through an optimised time-dependent modulation of the lattice position, we can tailor the collective wavefunction of the condensate [1]. Using this tool, we can prepare, in the phase space of each lattice site, a variety of translated and squeezed Gaussian states, and superpositions of Gaussian states.
Complete reconstruction of these non-trivial states is performed through a maximum likelihood state tomography, demonstrating an efficient preparation [2]. We thus achieved the preparation of states inaccessible using adiabatic methods. We have also investigated how to use optimal control to stabilize the prepared states stroboscopically.

Besides these recent results, I will discuss perpectives opened by these control tools in the preparation of states for quantum simulation, or, in a metrological context, the enhanced detection of a parameter.

[1] N. Dupont, G. Chatelain, L. Gabardos, M. Arnal, J. Billy, B. Peaudecerf, D. Sugny and D. Guéry-Odelin, PRX Quantum 2, 040303(2021)
[2] N. Dupont, F. Arrouas, L. Gabardos, N. Ombredane, J. Billy, B. Peaudecerf, D. Sugny, D. Guéry-Odelin, New Journal of Physics, 25, 013012 (2023)

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