Machine learning optimised stirring of persistent currents in BECs

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Persistent currents in Bose-Einstein condensate superfluids are useful for developing highly sensitive compact atom-wave interferometers, primarily for inertial sensing purposes [1]. Persistent currents can be generated through phase imprinting [2], LG laser mode angular momentum transfer [3] and stirring through an optical barrier [4]. Stirring is the most intuitive approach when engineered optical potentials are available, but the best stirring parameters are not immediately apparent. In this work, we apply a Gaussian process learner via M-LOOP [5] to find optimum stirring parameters experimentally. Four different stirring protocols are considered: targeting and maximisation of the persistent current winding number without any time limitations, as well as targeting and maximisation under strict time limitations. In all four cases, the learner attempts to produce a persistent current according to the constraints while also reducing the number of spurious vortices introduced by stirring. We find that the learner is successful in optimising the stirring protocols in the unrestricted time cases, while the optimisation is successful for the restricted time cases given the limitations of the chosen cost functions. We also note significantly different optimal stirring profiles between each optimisation, where acceleration of the stirring barrier is no longer constant as would be the intuitive prediction. The clear differences in the optimised protocols suggest the lack of a universal stirring method, indicating a level of robustness in using stirring to prepare persistent currents.

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