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Improving the sensitivity of a multi-state interferometer

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Matter–wave interferometry is a powerful tool for high-precision measurements of the quantum properties of atoms, many-body phenomena and gravity. It exploits the excellent localization in momentum space and coherence of degenerate gases. Here we present experimental results obtained on a multi-state interferometer, realized with a Rubidium Bose-Einstein Condensate on a compact and easy to use atom-chip device. Using optimal control techniques, we want to create optimal input states to achieve the maximal phase sensitivity of the interferometer, limited by the Cramer-Rao lower bound on its variance. Furthermore, we investigate the scaling of the phase sensitivity with the number of paths of the interferometer. To this end we exploit advanced quantum control techniques to effectively vary the number of states, i.e. the number of paths, of our interferometer. Our high-sensitivity interferometric schemes permit a thorough investigation of light–atom and surface–atom interactions and is applicable to multi-parameter sensing schemes in cold-atom interferometry.