Optimal atom-interferometric dark-matter detectors

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Atom interferometers are based on coherent manipulation of the center-of-mass motion of atoms and have developed into a high-precision tool for inertial sensing and tests of fundamental physics. As quantum objects, their internal degree of freedom can be manipulated as well, which opens the avenue for new tests of possible dark-matter candidates. In fact, differential setups allow for probing and comparing different points in spacetime and different amplitudes of ultralight dark-matter fields. Due to their differential nature, the sensitivity of such detectors depends on their dimension, so that devices with long baselines are an emerging field [1].

Starting from fundamental interactions of atomic constituents with dark matter candidates, we demonstrate which atom interferometers are in principle susceptible and which type of manipulation method should be preferred [2]. Assuming the most advantageous configuration, we present different detection modes and demonstrate how to optimize the detector baseline to achieve the highest sensitivity [3].

[1] AVS Quantum Sci. 6, 024701 (2024)

[2] AVS Quantum Sci. 5, 044404 (2023)

[3] AVS Quantum Sci. 6, 014404 (2024)