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Matter-wave interferometry with Rb atoms

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Abstract
Matter-wave interferometry is well understood, and there have been several experimental demonstrations | even with particles as large and complex as molecules. While the centre of mass (COM) motion of such particles is controlled very precisely, internal spin properties can aect the motion if both degrees of freedom are coupled. This can be used in a twofold way: it can map the spin properties onto the COM motion to analyse them, or it can be used to manipulate the COM motion. A far future goal of this coupling can be to show quantum entanglement of external with internal degrees of freedom. We will report on our approach to understanding the details of magnetic coupling of the COM motion of particles to their spin. We nd that the properties of Rb atoms make them a very appropriate test species with which to prototype novel interferometric techniques involving magnetic spin-COM coupling, and we propose some examples of such new techniques and explain how we intend to realise them experimentally. We also analyse and simulate the proposed experiments using a recently developed theoretical formalism that provides an extension of the Wigner function description of matter wave propagation to particles whose internal state strongly infuences their interactions with externally applied elds. Extension of these techniques to much larger particles than atoms opens the door to test the foundations of quantum theory.

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