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Reading the phase of a Raman excitation with a multi-state atomic interferometer

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Matter-wave interferometry is a powerful tool for high precision measurements in quantum computations and simulation protocols. We present here the detection of the phase of a Raman excitation by means of atomic interferometry. A standard Ramsey-like interferometric technique has been implemented with a Bose-Einstein condensate of 87Rb atoms on an atom chip. In our scheme the states of a spin-orientation manifold of a single hyperfine level were connected by two different coupling methods: a light-driven Raman excitation and an RF-driven magnetic dipole excitation. The strong RF coupling made possible by our atom chip setup was exploited to detect the phase imprinted on the atomic wave function by the previously applied Raman pulse. The interference of all the five spin-orientation sublevels of the hyperfine state enhanced our sensitivity with respect to a simple two-path interferometer. This way we experimentally demonstrated that both, a Raman transition imprints a distinct, controllable phase on the atomic coherence, and that it can be recovered after a variable time delay.