# Cavity optomechanical detection of persistent currents in ring-trapped Bose-Einstein condensate

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We introduce a novel approach for detecting the rotation of persistent current in an annularly trapped Bose-Einstein condensate. Our method integrates the concepts of cavity optomechanics with atomic superfluid rotation, allowing for an in situ, in real-time, and minimally destructive detection of the condensate rotation. This is in contrast to currently used methods that completely destroy the condensate. Cavity optomechanics involves the coupling of mechanical motion to electromagnetic fields confined in resonators. By utilizing dispersive light-matter interaction, our approach facilitates minimally destructive measurements of persistent currents. Specifically, we consider a ring-trapped BEC interacting with an optical cavity mode that carries orbital angular momentum. The optical cavity induces Bragg scattering among the atoms in the condensate, leading to BEC density modulation due to the interference among different rotational states. The transmitted light from the cavity picks up these modulations, and the resulting cavity output spectrum reveals the winding number of the persistent current. We employ a mean-field stochastic Gross-Pitaevskii simulation technique to model the persistent current for weakly repulsive interatomic interactions. The cavity transmission spectra, which contain signatures of condensate rotation, are obtained. We also analyze the sensitivity of rotation measurement as a function of the system's response frequency that demonstrates the effectiveness of this optomechanical configuration as a rotation sensor, revealing that the best sensitivity of our method to the BEC rotation is three orders of magnitude better than other available proposals. Our method can have significant implications for characterizing rotating matter waves across various fields, including atomtronics, superfluid hydrodynamics, matter-wave soliton interferometry, and optomechanical sensing.