Dynamics of massive superfluid vortices

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Quantum vortices are generally thought of as funnel-like holes around which a quantum fluid exhibits a swirling flow. In this picture, vortex cores are empty regions where the superfluid density goes to zero. Here we generalize this framework, by allowing the vortices to have a non-zero mass. The latter may arise for example due to atoms which are distinguishable from the ones composing the superfluid, or are excited out of it as a result of thermal or quantum fluctuations and remain trapped in the vortex cores. Providing vortices with a mass alters dramatically their dynamics, since the particles trapped in the vortex core experience an effective synthetic gauge field provided by the surrounding superfluid component, which leads to a density-dependent synthetic magnetic field.

In a hard-walled cylindrical container and on an annulus the additional mass leads to a modification of the precession frequency, and the usual precession turns into a cyclotron motion, which for large mass eventually becomes unstable. In a generic trapping potential $V \propto r^k$, the dynamics acquires an additional intriguing feature which may be easily observed: the direction of precession changes sign for sufficiently large mass [3].

Dynamics of massive point vortices in a binary mixture of Bose-Einstein condensates

Massive superfluid vortices and vortex necklaces on a planar annulus

Dynamics of a massive superfluid vortex in $r^k$ confining potentials