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Kelvin wave generation on vortices in Bose-Einstein condensates

SCOTT STRONG, Applied Mathematics and Statistics, Colorado School of Mines, LINCOLN CARR, Department of Physics, Colorado School of Mines — Understanding the dynamics of a single line of concentrated vorticity is an open and fundamental problem in the study of superfluid turbulence. The local induction approximation, or LIA, is a straightforward integrable model of curvature induced flow. Here, the curvature and torsion evolve under a cubic focusing nonlinear Schrödinger equation whose wealth of conservation laws are thought to artificially constrain interactions between helical modes. Our work describes LIA as the lowest-order approximation in a fully nonlinear expansion of curvature induced motion honoring arclength conservation present in the Hamiltonian formulation of inviscid fluid dynamics. These higher-order corrections are accurate at scales where LIA is not, and accounts for non-locally induced flows and contributions due to the vortex core. Our fully nonlinear model predicts that traveling waves of localized curvature seek to transport bending along the vortex. Simulations show dynamics similar to those seen post-reconnection in vortices generated by obstacles and cavitation in classical flows. In ultraquantum turbulent tangles, energy transfer between helical Kelvin modes of vortex lines permits free decay and our relaxation of bending via Kelvin wave generation may be its most primitive manifestation.

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