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Emergent vortex dynamics in two-dimensional neutral superfluids CHENG-CHING WANG, Dept. of Physics, Univ. of Texas at Austin, REMBERT DUINE, Inst. for Theoretical Physics, Utrecht University, MACDONALD ALLAN, Dept. of Physics, Univ. of Texas at Austin — We derive an effective action for the vortex translational zero modes of a superfluid by integrating out environmental modes which include phase and density fluctuations of the condensate. When the quantum dynamics of the fluctuations are treated as frozen with negligible Berry phases in adiabatic limit, we confirm the occurrence of vortex Magnus force and adiabatic vortex mass due to compressibility of the superfluids in agreement with earlier studies. In addition, we also show the results beyond adiabatic limit in which the quantum dissipative action can be derived and solved analytically. We show that the adiabatic approximation is only valid in large system with small coherence length $R \gg \xi$. Furthermore, we also build a numerical model based on discrete Gross-Pitaevskii equation to show the renormalization and broadening of the vortex cyclotron resonance peaks. It is demonstrated that well-defined cyclotron peaks in spectral functions can be sustained only when the condition $R \gg \xi$ is satisfied. With the mapping between discrete Gross-Pitaevskii equation and bosonic single-band Hubbard model, we propose that the adiabatic vortex dynamics can be realized by tuning the ratio between tunneling energy J and on-site interaction energy U such that $UN_a \gg J$ in cold atom systems with optical lattices, in which N_a is the total number of bosonic atoms.

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