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Tkachenko Modes of the Square Vortex Lattice in a two-component Bose-Einstein Condensate

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Abstract: We study Tkachenko modes of the square vortex lattice of a two-component Bose-Einstein condensate (BEC) in the mean-field quantum Hall regime, considering the coupling of these modes with density excitations. We derive the hydrodynamic equations and obtain the dispersion relations of the excitation modes. We find that there are two types of excitations, gapped inertial modes and gapless Tkachenko modes. These modes have two branches which we call acoustic and optical modes in analogy with phonons. The former has quadratic while the latter has linear wave-number dependence in both inertial and Tkachenko modes. Acoustic Tkachenko mode is found to be anisotropic while the other three modes are isotropic. The anisotropy of the acoustic Tkachenko mode reflects the four-fold symmetry of the square lattice.

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