Vortex Lattices in Polariton Quantum Fluids

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Résumé

Topological defects such as quantized vortices are one of the most striking manifestations of the superfluid nature of Bose-Einstein condensates and spectacular examples of quantum mechanical phenomena on a macroscopic scale. Here we investigate such effects in exciton-polariton systems, the bosonic quasiparticles arising from the strong coupling between photons and excitons in a semiconductor microcavity. Due to their low effective mass and the easy control by means of optical techniques they provide an exceptional playground for the study of the quantum properties of interacting Bose gases and of their topological excitations. We demonstrate the formation, in a controllable way, of a lattice of vortex-antivortex pairs. Moreover, we study for the first time its properties in the intermediate and high-density regimes where polariton-polariton interactions dominate the behaviour of the system. In the intermediate case, polariton-polariton repulsion strongly deforms the lattice unit cell and determine the pattern distribution of the vortex-antivortex pairs, showing a completely new behaviour with respect to geometrically generated vortex lattices, whose shape is determined only by the geometry of the system. Instead, at high polariton densities the fluid reaches a regime where the the formation of vortex-antivortex pairs is inhibited and the complete destruction of the organized pattern of topological defects is observed. Finally we study the correlations between the subsonic character of the superfluid and the quenching of the vortex lattice.

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