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Quantization of Angular Momentum in Rotating Polariton Superfluid

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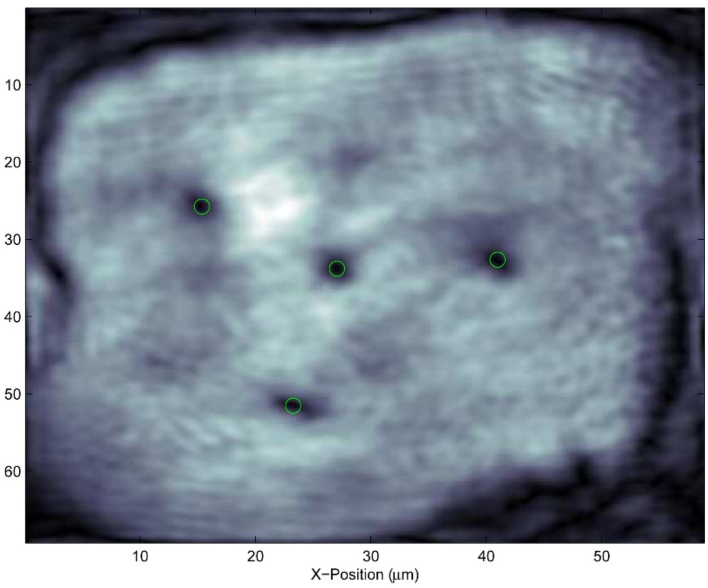
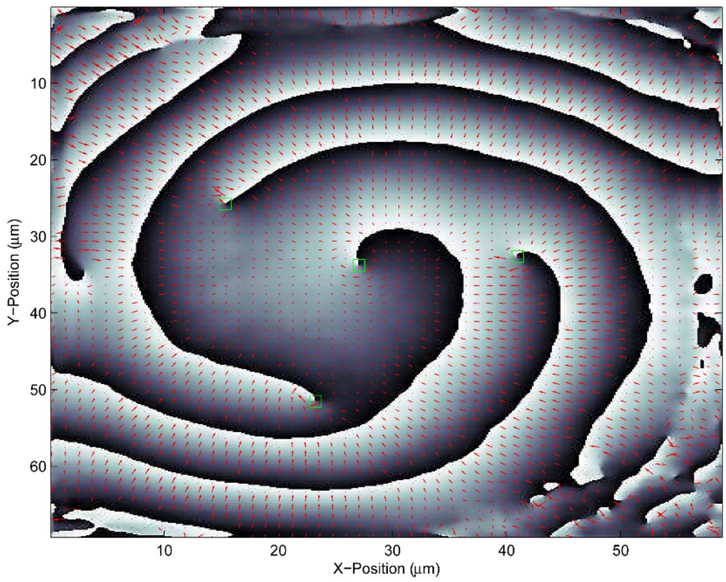
Abstract:

Quantized vortices are topological excitations characterized by the vanishing of the field density at the vortex core and by the quantized winding of the field phase from 0 to 2π around it. They have been extensively studied and observed in non-linear optical systems, superconductors, superfluid 4 He, vertical-cavity surface-emitting lasers, and more recently in cold atoms where, as predicted by Abrikosov, vortices tend to arrange in triangular lattices due to their mutual interactions. Finally, in recent years, the study of vortices and vortex lattices has attracted much attention also in the field of coherent light-matter systems, like polaritons. Polaritons are half light-half matter bosonic particles arising from the strong coupling between excitons and photons in a semiconductor microcavity.
Polariton systems are ideal systems to study out of equilibrium quantum fluid phenomena. In analogy with the atomic case the superfluid behaviour of Bose-Einstein polariton condensates has been of great theoretical and experimental interest. In particular, cavity- polariton systems have been predicted and shown to undergo formation of stable vortices, half-vortices and single vortex-antivortex pairs.





Figures: (a) – Real space image of the superfluid: Density map of the superfluid's steady state (CW resonant pumping). An angular momentum with quantum number l=4 is injected, and results in the apparition of 4 elementary vortices, visible as holes in the density. **(b) – Phase gradient:** Phase map associated to Fig.(a). The phase gradient is proportional to the fluid's velocity and vortices are visible as phase singularities.

We have studied vortex-antivortex lattices with zero angular momentum trapped by an optically controllable potential. We addressed theoretically and observed experimentally the effects of the polariton-polariton non-linear interactions on the shape of the lattice of vortices. Recently, we observed that the injection of a non-zero angular momentum in a polariton superfluid, through different techniques, results in the apparition of elementary vortices collectively carrying the injected angular momentum. We were able to obtain an array of vortices of the same sign (no antivortices), whose spatial distribution can be studied against trap potential geometry, polariton-polariton interactions, and cavity disorder. The efficiency and drawbacks of the different methods of angular momentum injection are discussed.