Persistent currents and quantised vortices in a matter-light superfluid

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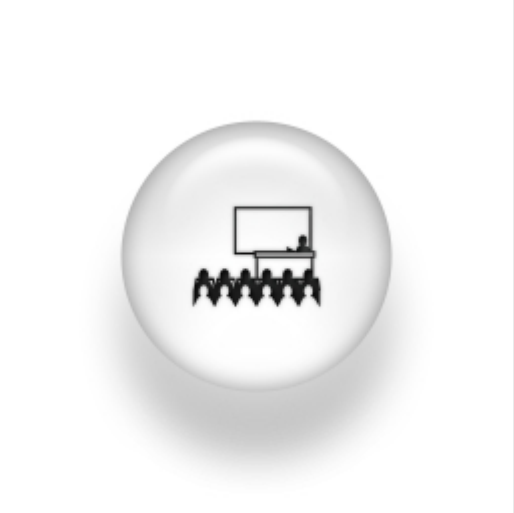

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ABSTRACT:
Bose-Einstein condensation and superfluidity has been recently revealed in semiconductor microcavities [1,2], inaugurating a new era in the study of strongly coupled light-matter systems. The intrinsic non-equilibrium component enriches the features of such a system and at the same time poses fundamental questions about the properties of a superfluid in a dissipative environment. For example, differently from an equilibrium superfluid, characterised by a flowless ground state, pump and decay in microcavities causes supercurrents even in the steady state regime. I will consider the case of resonantly driven polariton microcavities in the optical parametric oscillator (OPO) regime and report the first observation of a metastable persistent superflow carrying quantum of orbital angular momentum~[3]. The non-equilibrium superfluid can hold a metastable vortex state generated with an external laser and the polariton circulating superfluid persists in absence of the driving rotating probe. The experimental results are compared to, and explained by, a theoretical analysis~[3,4] obtained describing the parametric scattering regime of polaritons via a two-component Gross-Pitaevskii equation, including pump and decay processes. In addition to metastable vortex solutions, which can only be triggered externally, I will show the possibility for stable vortex solutions, where the OPO system undergoes spontaneous symmetry breaking and is unstable towards vortex formation without any driving rotation. To conclude, I will analyse the stability of doubly charged vortices.
[1] J. Kasprzak et al., Nature 443, 409 (2006); R. Balili et al., Science 316, 1007 (2007).
[2] A. Amo, D. Sanvitto et al., Nature 457, 291 (2009); A. Amo et al. Nature Phys. 5, 805 (2009).
[3] D. Sanvitto, F. M. Marchetti et al., Nature Phys. to appear (preprint arxiv:0907.2371).
[4] F. M. Marchetti et al., preprint arxiv:1003.5111.