Polariton condensation, superfluidity and quantum hydrodynamics

Polaritons are half-light half-matter quasiparticles arising from the strong coupling between quantum well excitons and photons confined in a monolithical semiconductor microcavity. The interest of polaritons lies in the fact that they combine the properties of both of their constituents: from their excitonic part, polaritons strongly interact with each other, while from their photonic part polaritons inherit a very small effective mass (10^-4 the electron mass), and they can be directly excited and observed via light absorption and emission, accessing all the information related to their density, frequency, phase, and spatial and temporal coherence. Their very light mass along with their composite-boson nature makes polaritons very attractive to study bosonic condensation (BEC), that is, the macroscopic accumulation of particles in the same quantum state. In this colloquium I will review the main properties of polariton condensates and show our recent experiments on the quantum hydrodynamics of polariton fluids. Indeed, polariton-polariton interactions give rise to fascinating quantum fluid phenomena like flow without friction or the nucleation of solitons and quantized vortices when the fluid is perturbed. Polaritons present an extraordinary workbench to study bosonic condensates using partly photonic particles. The photonic nature of polaritons actually allows us to manipulate these bosonic condensates using light, and to create integrated polariton circuits controlled all optically.

Dark soliton formation in a polariton condensate encountering an obstacle in its flow path. The image is obtained directly from the real space light emission of the polariton condensate out of the microcavity. From Amo et al. Science 332, 1167 (2011).