

Superfluidity, Localisation and Josephson effect of spinor cavity polaritons.

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In this work, we present the derivation of the spinor Gross Pitaevskii equation and we review the main properties of the Bose Condensate of cavity polaritons, taking into account their unique spin structure.

We demonstrate that the polariton polarisation is the true order parameter of the Bose Einstein condensation. In the case of GaAs and CdTe microcavities, at equilibrium the condensate is linearly polarised [1,2] because of the anisotropy of the polariton-polariton interaction. The excitation spectrum of the condensate (Bogoliubov modes) is composed by two distinct branches, which are moreover anisotropic in space because of the interplay of the broken symmetry state of the condensate and the isotropic splitting existing between the TE and TM polarised modes [3]. In contrast, bulk GaN cavities [4] are characterised by isotropic polariton-polariton interaction because of the mixing between the heavy and light hole excitons, usually labelled A and B. As a result, any polarisation state, including the circular one can be randomly chosen during the symmetry breaking process leading to the appearance of the order parameter.

In the second part we analyse the impact of the in-plane potential on the superfluid properties of polaritons. We first consider the simple situation of two coupled potential wells and describe two different types of Josephson effects: the extrinsic effect, related to the coherent tunneling of particles with the same spin between two spatially separated potential traps, and the intrinsic effect, related to the "tunneling" between different spinor components of the condensate within the same trap [5]. We show that the Josephson effect in nonlinear regime can lead to nontrivial polarization dynamics and produce spontaneous separation of the condensates with opposite polarization in real space. As a second step we consider the more complex situation of a condensate moving in a random extended potential [6]. We show that the condensation is accompanied by the onset of Anderson localisation recently observed experimentally for cold atomic systems [7,8]. We describe the formation of the Anderson Glass, which is gapless, phase coherent, but which shows no superfluidity. Contrary to the Bose Glass phase, the increase of the interaction strength (which can be achieved for polariton systems by increasing the polariton density) tends to delocalize the condensate, which can eventually percolate to form a superfluid phase.

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