Département de Physique
École normale supérieure

LPENS
Laboratoire de Physique de l'ENS

Séminaire d'axe Matériaux et Dispositifs Quantiques (MDQ)
Lundi 18 Février, 11h00-12h00, Conf. IV

Quantum Fluids of Exciton-Polaritons

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There is a growing interest in the study of polaritonic systems, mixed states of photons and excitons, for both, the observation of quantum macroscopic phenomena, and the realisation of all-optical devices that could offer limitless advantages in terms of energy consumption, dissipation-less operation and high clock frequencies [1]. More recently, by entangling one photon with one polariton, it has even been shown that these quasiparticles can also be ideal carriers of quantum information [2].

Here we show several macroscopic quantum phenomena that can be observed in polariton condensates, both at low temperature, in inorganic semiconductor microcavities–for which the very long lifetime can show behaviour associated to the Berezinskii–Kosterlitz–Thouless (BKT) regime [3], typical of 2D equilibrium system–and in organic based polaritons, where superfluidity can be observed at room temperature in spite of the marked open, driven dissipative, nature of these polariton condensates [4]. We also show the possibility of using hybrid semiconductors with reduced dimensionality to achieve the regime of highly interacting polaritons. These materials include monocrystalline two-dimensional perovskites and transition metal dichalcogenides that have demonstrated nonlinear responses similar to those of low temperature inorganic semiconductors. Finally, we will speculate on the possibility to reach the genuine quantum regime using single polaritons as quantum bits for the implementation of photonic nonlinear quantum devices.

References

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[4]. Lerario, G. *et al.* Room-temperature superfluidity in a polariton condensate. *Nat Phys* **13,** 837 (2017).