

Quantum polariton fluid in microcavities

D. Sanvitto¹, A. Amo^{1,*}, D. Ballarini¹, M. D. Martin¹, L. Vina¹, F. P. Laussy^{2,*}, E. Del Valle², C. Tejedor², M. Wouters³, I. Carusotto⁴, A. Lemaitre⁵, J. Bloch⁵, D. N. Krizhanovskii⁶, M. S. Skolnick⁶

¹ Dep. Física de Materiales, Univ. Autónoma de Madrid, 28049 Madrid, Spain.

² Dep. Física Teórica de la Materia Condensada, Univ. Autónoma de Madrid, 28049 Madrid, Spain.

³ Institute of Theoretical Physics, Ecole Polytechnique Fédérale de Lausanne EPFL, CH-1015 Lausanne, Switzerland

⁴ BEC-CNR-INFN and Dipartimento di Fisica, Università di Trento, I-38050 Povo, Italy

⁵ LPN/CNRS, Route de Nozay, 91460, Marcoussis, France.

⁶ Dep. Physics & Astronomy, Univ. of Sheffield, S3 7RH, Sheffield, U.K.

* Present address: Laboratoire Kastler Brossel, Université Paris 6, Ecole Normale Supérieure et CNRS, UPMC Case 74, 4 place Jussieu, 75252 Paris Cedex 05, France

* Present address: University of Southampton, Dept. of Physics & Astronomy, High-field Campus, Southampton, SO17 1BJ, UK.

Coherent collective behaviours of microcavity polaritons have recently shown close analogies with Bose condensates of atoms. In this work we will show the possibility to observe the dynamics of the elementary excitations of a coherent state of polaritons and the interesting phenomenology when this state is put in motion.

A very intriguing behaviour of the elementary excitations of the signal polaritons, created by resonantly exciting on the lower branch, is the strong decrease of the dumping rate when approaching from below the threshold power for the stimulated parametric scattering [1]. Using a combination of continuous wave (CW) excitation and pulsed probe, we are able to observe a slowing down of the dynamics of the signal elementary excitations by more than three orders of magnitude with respect to the empty cavity lifetime. This phenomenon is associated to the onset of a soft Goldstone mode when the threshold is crossed [2].

Thanks to the very long lifetime of the signal, by stimulating the parametric scattering at finite wavevectors, we demonstrate the possibility to create a coherent polariton flow travelling inside the CW pump [3,4]. A first finding is the linearization of the polariton dispersion around the signal state that results in a diffusionless motion of the polariton wavepacket travelling at velocities around 1% the speed of light. In spite of the very high velocity, the coherent polariton signal can show unperturbed motion when crossing a potential barrier, as well as quantum reflection and splitting when the size of the defect becomes comparable to that of the polariton droplet.

The complex phenomenology of the quantum fluid of polaritons, which shows similarities with the well known physics of ultra-cold atomic gases—such as Bose Einstein condensation and superfluidity—stimulates further investigation of the novel characteristics of non-equilibrium, strongly interacting, coherent polariton states.

References

[1] D. Ballarini *et al.*, [arXiv:0807.3224](https://arxiv.org/abs/0807.3224) (2008).

[2] M. Wouters and I. Carusotto, *Phys. Rev. A*, **76**, 043807 (2007).

[3] A. Amo *et al.*, [arXiv:0711.1539](https://arxiv.org/abs/0711.1539).

[4] F. P. Laussy, oral contribution at this conference