Physics of heat transfer with a nonequilibrium quantum fluid of polaritons

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(ENGLISH BELOW) Exciton-polaritons in semiconductor microcavities have been nowadays well established as a new class of quantum fluids, with defining phenomena such as Bose-Einstein condensation and Superfluidity [1]. Unlike ultra-cold atoms or liquid Helium, this unique class of fluid is characterized by the fact that the particles lifetime is too short to reach thermal equilibrium, and thus are not constrained by it.

This feature opens up unconventional mechanisms of heat exchange between the fluid and its solid-state environment (thermal phonons). In this talk, I will present an experimental work showing that a polariton fluid can be pumped in a "cold" state, in which it absorbs heat from the warmer phonon bath and releases it into the (much colder) electromagnetic vacuum. The irreversibility of this mechanism is a direct consequence of the fluid nonequilibriumness [2].

In the latter regime, the heat flux was negligible as compared to the particle loss rate. We thus examined experimentally the strong heating regime, in which heat, drive and losses contribute equally in establishing the fluid steady-state. We characterized how the normal to condensed phase transition is affected by the amount of absorbed heat, and how heat is "stored" in the condensate degrees of freedom, in a way that is not fixed by an equilibrium distribution [3].

[1] I. Carusotto and C. Ciuti, Quantum fluids of light, Rev. Mod. Phys. **85**, 299 (2013).
[2] S. Klembt *et al.* Exciton-Polariton Gas as a Nonequilibrium Coolant, Phys. Rev. Lett. **114**, 186403 (2015).
[3] S. Klembt *et al.* Thermal Decoherence of a Nonequilibrium Polariton Fluid, Phys. Rev. Lett. **120**, 035301(2018).

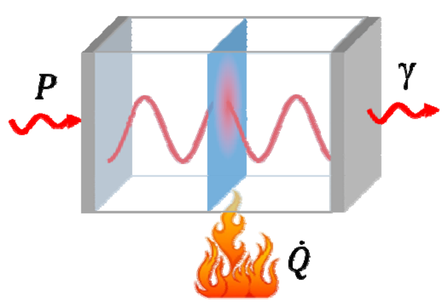

Figure 1: Sketch illustrating the specific nonequilibrium situation of polariton fluids. P is the polariton excitation rate achieved by an external optical source, γ is the loss rate, and $\dot{Q}$ is the heating rate of polaritons.