Flow of an exciton-polariton condensate in optical microcavities with the natural structural disorder

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Exciton-polaritons are coherent quasiparticles that emerge from the strong interaction between cavity photons and quantum well excitons in semiconductor microcavities. The hybrid nature of these quasiparticles leads to strong nonlinear interparticle interactions and excellent transport properties. Recently, experimental studies have reported the observation of nontrivial dynamical effects in microcavities with a structural disorder, including relaxation oscillations and the generation of nonlinear waves [1]. The observed effects may be used in optical information processing in the future. Nevertheless, the precise control of polariton flow in a microcavity with inhomogeneous potential is still challenging.

Here, we investigate the formation of exciton-polariton condensate currents in a microcavity with a built-in structural disorder Fig. 1 a). We focus on forming polariton condensates under nonresonant excitation in an asymmetric potential trap. We demonstrate that the flow and counterflow of condensates inside a double quantum well can be precisely controlled by the intensity of laser sources acting on each potential minimum Fig. 1 b). This control is made possible by the optical anti-trapping potential created by an incoherent excitonic reservoir. Our theoretical model is based on the generalized open-dissipative Gross-Pitaevskii equation coupled with the exciton-polariton reservoir of excitons and hot carriers. Our analysis accurately reproduces the experimental results and provides insights into the fully optical, precise control of exciton-polariton networks. Our study can be helpful in the development of novel optoelectronic devices based on exciton-polaritons.

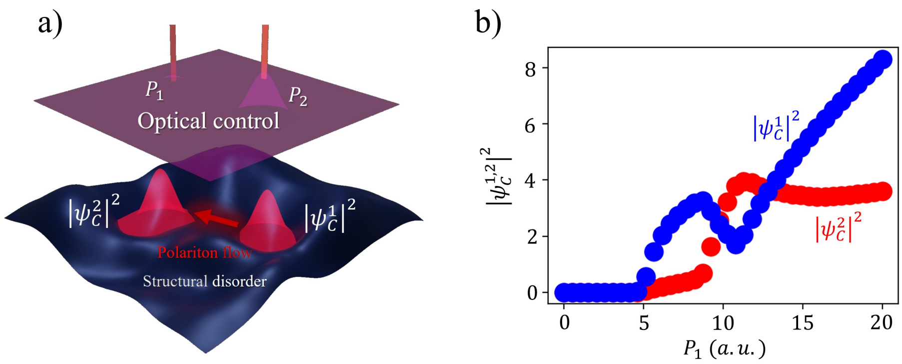

Fig. 1 – Optically controlled polariton condensate flow between two potential minima occurring due to natural structural disorder a). Emission intensity from simultaneously excited condensation sites when P_2 is constant b).

[1] M. Pieczarka, M. Syperek, Ł. Dusanowski, et al., *Sci Rep* **7**, 7094 (2017).