Revealing the THz fine structure of an exciton-polariton condensate

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The internal structure of quantum fluids such as condensed bosons formed by elementary excitations has remained largely elusive, though important information on the nature and dynamics of the condensing quasiparticles may be encoded therein. For the prominent example of exciton-polaritons only the photon component has been resolved, while the exact role of the excitons remained unclear. Here, we trace the matter component of condensing polaritons by monitoring intra-excitonic terahertz transitions. We study how a reservoir of optically dark excitons forms and feeds the degenerate state. Unlike atomic gases, the atom-like transition in excitons is dramatically renormalized on macroscopic ground state population. Our results prove the macroscopic population of the ground state, establish intrinsic differences between polariton condensation and photon lasing, and provide a new access to macroscopic wavefunctions [1].

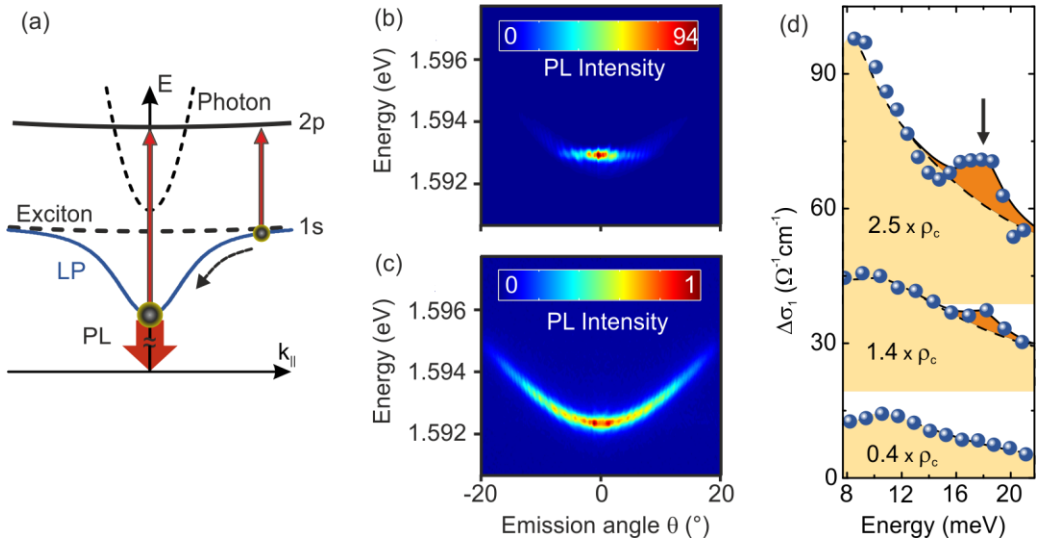

Figure 1 (a) THz absorption probes intra-polaritonic transitions. (b, c) PL measurements as function of energy and angle of emission θ taken for excitation densities below (c) and above (b) the threshold density ρ_c. (d) Real part of the pump induced THz conductivity $\Delta\sigma_1$ for different excitation densities ρ below and above threshold. Beside the existence of the reservoir 1s-2p transition an additional resonance at 18 meV (black arrow) points to a macroscopic population of the lower polariton (LP) ground state occurring above threshold.

[1] Ménard, J.-M., Poellmann, C. *et al*. Revealing the dark side of a bright exciton-polariton condensate. Nature Communications **5**, 4648 (2014).