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Superfluid Phase Transition of Long-Lifetime Polaritons[1]

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Exciton-polaritons are quanta of electronic excitation which can have their properties tailored in semiconductor structures to have extremely light mass, about four orders of magnitude less than a free electron. One can think of them as photons dressed with an effective mass and an atom-like interaction. Because of their very light mass, exciton-polaritons show Bose quantum effects even at moderate densities and temperatures from tens of Kelvin up to room temperature. In the past five years, multiple experiments have shown effects of polaritons analogous to Bose condensation of cold atoms, such as a bimodal momentum distribution, quantized vortices, a Bogoliubov excitation spectrum, spatial condensation in a trap, and Josephson junction oscillations. In these experiments, though, the lifetime of the polaritons has been just a little longer than their thermalization time, which means that nonequilibrium effects play an important role; in particular, the transition to superfluidity has been smeared out rather than a sharp transition. In this talk I report new results with polaritons that have very long lifetime compared to their thermalization time. We see a discontinuous jump in the properties of the polariton gas indicative of a true phase transition, and we see ballistic transport over hundreds of microns. We also now have a way to use a laser to create a potential barrier for the polaritons.

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