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Bose-Einstein condensation of photons

JAN KLAERS, Institut fur Angewandte Physik, Universitat Bonn, Wegelerstr. 8, 53111 Bonn, Germany

In recent work, we have observed Bose-Einstein condensation (BEC) of a two-dimensional photon gas in an optical microcavity [1]. Here, the transversal motional degrees of freedom of the photons are thermally coupled to the cavity environment by multiple absorption-fluorescence cycles in a dye medium, with the latter serving both as a heat bath and a particle reservoir. The photon energies in this system are found to follow a Bose-Einstein distribution at room temperature. Upon reaching a critical total photon number, a condensation into the transversal ground state of the resonator sets in, while the population of the transversally excited modes roughly saturates. The critical photon number is experimentally verified to agree well with theoretical predictions. Owing to particle exchange between the photon gas and the dye molecules, grandcanonical experimental conditions can approximately be realized in this system. Under these conditions, two markedly different condensate regimes are theoretically expected [2]. On the one hand, this includes a condensate with Poissonian photon number statistics, being the analog to present atomic Bose condensates. Additionally, we predict a second regime with anomalously large condensate fluctuations accompanied by a Bose-Einstein-like photon number distribution that is not observed in present atomic BEC experiments. The crossover between these two regimes, corresponding to the emergence of second-order coherence, depends on the size of the molecular reservoir (e.g. the dye concentration) and is expected to occur at a temperature below the BEC phase transition. In my talk, I will give an update on our experimental work.

[1] J. Klaers, J. Schmitt, F. Vewinger, and M. Weitz, *Nature* **468**, 545 (2010)
[2] J. Klaers, J. Schmitt, T. Damm, F. Vewinger, and M. Weitz, *Phys. Rev. Lett.* **108**, 160403 (2012)