Towards Quantum Polaritonics with Fibre-Cavity Polaritons

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Over the past decade, exciton-polaritons in semiconductor microcavities have attracted a great deal of interest as driven-dissipative quantum fluids [1]. They offer themselves as a versatile platform for performing Hamiltonian simulations with light as well as for experimentally realizing nontrivial out-of- equilibrium phase transitions. The key ingredient at the basis of these phenomena is the fact that polaritons interact with each other. In the regime of large two-body interactions, polaritons can be used to manipulate the quantum properties of a light field. A regime of particular interest that has remained elusive so far is the one for which the interactions are large enough to show up in the system response at the level of few quanta, signified by the presence of quantum correlations between the emitted photons [2,3].

In this talk, I will report on the experimental observation of such correlations in resonant laser light transmitted through a fiber-cavity polariton system [4], indicating the onset of the strong interaction regime [5]. We observe a dispersive shape of the photon autocorrelation function including weak antibunching around the polariton resonance which is a characteristic signature of this phenomenon. From the photon autocorrelation data, we are further able to extract a value for the polariton-polariton interaction constant. Owing to their weak amplitude, the observed quantum correlations remain far from a fully- developed Fock state of light with low photon number, but they still demonstrate the emergence of time- ordering in the photon stream.

Besides resonant measurements, we have also conducted experiments under off-resonant pumping of the fiber-cavity polaritons. Using a narrow-band filter for the emitted photons, we are able to again observe non-trivial quantum correlations from the off-resonantly pumped system. These findings, at first sight surprising, are supported by numerical simulations of the system dynamics.

Our works act as a door opener for the emerging field of quantum polaritonics [3]. With further improvements both on the photonics engineering and the materials engineering side, quantum well cavity polaritons might eventually become a platform of choice for turning laser light into single photons and for realizing strongly interacting quantum fluids of light for quantum simulations.

References:

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