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Close to perfect coupling of single photons to a single molecule in a microcavity

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The realization of future quantum networks will heavily rely on a strong interaction of single photons with single quantum emitters like atoms, molecules or quantum dots. Possible routes towards this goal include tight focusing [1], dielectric nano-waveguides [2] and microcavities [3]. The latter approach is particularly promising, because it can compensate for possible shortcomings of the emitter by exploiting effects of cavity quantum electrodynamics.

In this presentation we report on the efficient coupling of (single) photons to an organic molecule in a fiber microcavity. The system is operated at the onset of the strong coupling regime of cavity quantum electrodynamics, where a strong Purcell factor of 38 effectively turns the molecule into a two-level quantum system. We observe 99% extinction of a laser beam, which means that our molecule in the cavity acts almost as a perfect scatterer of photons [4]. The strong coupling also leads to a 66 degree phase shift on a laser beam, saturation of the molecule with about half a photon per fluorescence lifetime and a significant modification of the Lamb shift. Additionally we observe a very strong bunching behavior in the transmitted laser light, which can be used to realize a photon sorter.

We performed our experiments not only with a weak laser beam but also with true single photons. To do so, we generated single photons by a second organic molecule in another laboratory. These lifetime-limited single photons can be frequency tuned by the DC Stark effect and thus scanned across the frequency of the target molecule. We observe again a close to perfect extinction. Our experiments pave the way for building efficient linear and nonlinear quantum optical circuits based on organic molecules.

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