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Two quantum optics experiments in extreme parameter regimes

The Jaynes-Cummings model is central to the field of quantum optics. It serves well for the description of most cavity quantum electrodynamics experiments, and laid the foundations to perform qubit operations as required for quantum computation. Since a few years, however, there is a strong and growing interest to discover the physics beyond the Jaynes-Cummings regime, in theoretical studies as well as with novel experimental platforms.

The talk will cover two experiments exploring novel quantum optics regimes carried out using laser-cooled cesium atoms coupled to light guided in an optical nanofiber. In the first experiment, the nanofiber is a part of a 30-m long fiber ring resonator [1]. This allows us to enter the multimode strong coupling regime of cavity quantum electrodynamics. Here, the light–matter coupling rate is larger than the free spectral range of the cavity, and the atoms can simultaneously strongly interact with several longitudinal resonator modes. As a hallmark of multimode strong coupling, we observe a multi-mode Rabi splitting and study its dependence on key system parameters.

In a second experiment, we trap individual cold cesium atoms about 200 nm away from the nanofiber surface using detuned light fields propagating in the fiber. As shown in a recent proposal[2], the dynamics of the atoms in the trap is governed by the Quantum Rabi model: The atomic spin plays the role of the internal state of the emitters while the quantized center-of-mass motion of the trapped atom corresponds to the field of the electromagnetic mode. We experimentally show that these degrees of freedom are ultra-strongly coupled to each other in this system, i.e., that the coupling strength is a significant fraction of the trap frequency.

Beyond their fundamental interest, the results of our two experiments have the potential to lead to novel applications such as deterministic nonlinear optics or more robust quantum memories [3].

[1] P. Schneeweiss, S. Zeiger, T. Hoinkes, A. Rauschenbeutel, J. Volz, Opt. Lett. 42, 85 (2017)
[2] P. Schneeweiss, A. Dareau, and C. Sayrin, Phys. Rev. A 98, 021801(R) (2018)
[3] A. F. Kockum et al., arXiv:1807.11636

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I. épület, Tanácsterem

Az előadás nyelve: angol

Minden érdeklődőt szívesen látunk!