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**Measuring the dispersive interaction of an ensemble of Rydberg atoms with a cavity mode using circuit QED techniques** MATHIAS STAMMEIER, SEBASTIEN GARCIA, TOBIAS THIELE, ANDREAS WALLRAFF, Quantum Device Lab, ETH Zurich, JOHANNES DEIGLMAYR, JOSEF AGNER, HANSJUERG SCHMUTZ, FREDERIC MERKT, Laboratory of Physical Chemistry, ETH Zurich — Cavity quantum electrodynamics enables quantum nondemolition measurements of either part of the system, emitter or photon, by detecting the dispersive shift induced on the other part. This fact is exploited in many different physical systems. However using the dispersive shift of a microwave cavity to determine the state of a single Rydberg atom or an ensemble thereof is less explored. In our experiments, we measure the dispersive shift of a 3D cavity induced by an ensemble of singlet helium atoms in the 37s Rydberg state by detecting the microwave transmission of a weak probe tone. We observe a dispersive shift, the time dependence of which depends on the position-dependent collective coupling strength and the atom-cavity detuning as the atoms propagate through the cavity. The results agree well with the dispersive Tavis-Cummings Hamiltonian, and consistently imply maximal collective coupling strengths above 1 MHz, corresponding to approximately 3300 Rydberg atoms. We determine the scaling of the collective dispersive shift with the atom-cavity detuning and the number of Rydberg atoms, where the latter points towards the possibility of nondestructively measuring the number of Rydberg atoms.

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