Abstract Submitted for the DAMOP19 Meeting of The American Physical Society

Cavity protection of atomic qubits in the strong coupling regime. SYLVAIN SCHWARTZ, MOHAMED BAGHDAD, PIERRE-ANTOINE BOUR-DEL, FRANCESCO FERRI, ARTHUR LA ROOIJ, JAKOB REICHEL, ROMAIN LONG, Laboratoire Kastler Brossel — We have built a platform where ultracold rubidium atoms are strongly coupled to a fiber-based Fabry-Perot cavity under a high numerical aperture lens for single-qubit manipulation and readout. To maximize the overlap between the atomic distribution and the 780nm cavity mode to which they are coupled, we use an intracavity lattice trap at 1560nm in a configuration where the antinodes of the 1560nm field coincide with antinodes of the 780nm field, which is possible because the two wavelength are commensurate. With this device, we have observed vacuum Rabi frequencies on the order of 60MHz, corresponding to an effective single-atom cooperativity of about 40, limited by temperature but deep into the strong coupling regime. Because of their finite temperature, cold atom qubits in our setup have a random spatial distribution, which results in a random distribution of coupling parameters and resonance frequencies. In particular, the use of 1560nm trapping light implies strong energy shifts of the excited state manifold, typically 50 times bigger than ground state lightshifts. For our typical parameters, these inhomogeneities can be as large as several hundreds of MHz. Still, we observe transmission peaks of the atoms-cavity coupled system much narrower than this, on the order of a few tens of MHz. These observations are reminiscent of the cavity protection effect previously observed with spin ensembles coupled to superconducting microwave cavities, and reported here for the first time with atomic qubits.

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Date submitted: 01 Feb 2019

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