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Lossless qubit state detection of single neutral atoms MARTIN MÜCKE, JOERG BOCHMANN, CHRISTOPH GUHL, STEPHAN RITTER, DAVID L. MOEHRING, GERHARD REMPE, Max-Planck-Institute for Quantum Optics, Hans-Kopfermann-Str. 1, 85748 Garching, Germany, QUANTUM DYNAMICS DIVISION TEAM — Trapped neutral atoms are among the most promising resources for quantum information science. In a single trapped atom, the quantum bit (qubit) is typically encoded in or mapped onto atomic hyperfine states. However, hyperfine qubit read-out has proven remarkably difficult for neutral atoms. Existing protocols do not obtain an answer in every read-out attempt or suffer from loss of the atom during detection. We introduce a state detection scheme based on cavity-enhanced fluorescence. It makes use of the Purcell effect to establish a controlled coupling between qubit and environment. In an experiment with a single trapped Rubidium atom, we achieve a hyperfine state detection fidelity of 99.4 % in 85 μs while a result is obtained in every read-out attempt. Most important, the qubit can be interrogated many hundred times without loss of the atom. This presents an essential advancement for the speed and scalability of quantum information protocols based on neutral atoms. Our scheme can be generalized to all systems in which the qubit is optically accessible.

Martin Mücke
Max-Planck-Institute for Quantum Optics,
Hans-Kopfermann-Str. 1, 85748 Garching, Germany

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