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Deterministic Coupling of a Single Atom to a Nanoscale Optical Cavity LEE LIU, JEFF THOMPSON, Department of Physics, Harvard University, TOBIAS TIECKE, Department of Physics, Harvard University; Department of Physics, Center for Ultra-Cold Atoms and Research Laboratory of Electronics, MIT, NATHALIE DE LEON, Department of Physics, Harvard University; Departments of Chemistry and Chemical Biology, Harvard University, JOHANNES FEIST, ITAMP, Harvard Smithsonian Center for Astrophysics, MICHAEL GULLANS, Department of Physics, Harvard University, ALEXEY AKIMOV, Department of Physics, Harvard University; Russian Quantum Center, Skolkovo, Russia, ALEXANDER ZIBROV, Department of Physics, Harvard University, VLADAN VULETIC, Department of Physics, Center for Ultra-Cold Atoms and Research Laboratory of Electronics, MIT, MIKHAIL LUKIN, Department of Physics, Harvard University — Deterministic control over interactions between isolated ultra-cold atoms and nanoscale solid-state systems is an outstanding problem in quantum science. It is of interest for understanding the fundamental limits of quantum control over complex systems, as well as for realizing hybrid quantum systems, combining the excellent coherence properties atoms with strong interactions and scalability. We propose and demonstrate a technique for deterministically interfacing a single rubidium atom with a nanoscale photonic crystal cavity by trapping the atom in the near-field of the cavity. By controlling the atom's position, we probe the cavity field non-invasively with a resolution below the diffraction limit. A single-photon single-atom coupling rate of $2g \simeq 2\pi \times 0.5$ GHz is measured by a reduction in the cavity transmission. We discuss prospects for integrated, strongly-coupled quantum nano-optical circuits, and their potential applications.

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