Abstract Submitted for the DAMOP14 Meeting of The American Physical Society

A Nanophotonic Quantum Phase Switch with a Single Atom JEFF THOMPSON, TOBIAS TIECKE, THIBAULT PEYRONEL, NATHALIE DE LEON, LEE LIU, Harvard University, Department of Physics, KALI NAYAK, Center for Photonic Innovations and Department of Engineering Science, UEC Tokyo, The University of Electro-Communications, VLADAN VULETIC, MIT, Department of Physics and Research Laboratory of Electronics, MIKHAIL LUKIN, Harvard University, Department of Physics — In analogy to transistors in classical electronic circuits, quantum optical switches are the fundamental building blocks of quantum networks. They are important for many applications including quantum repeaters for long-range quantum communication, distributed quantum information processing and simulating quantum states of matter. We present recent experimental results on a scalable quantum optical switch consisting of a single atom trapped near a nanoscale photonic crystal cavity [1]. First, we show that the spin state of the atom controls the propagation of light through the switch, imposing a statedependent optical phase shift of  $\pi$ . Second, we show that a single photon incident on the switch can coherently change the state of the atom, allowing the switch to be gated from "on" to "off" with only a single quantum of input. Lastly, we demonstrate the truly quantum nature of the switch by showing that it acts differently on single photon inputs compared to photon pairs. These results and techniques pave the way towards large-scale integrated quantum nanophotonic networks involving multiple atoms situated near complex optical circuits.

[1] Thompson, J. D., Tiecke, T. G., *et. al.*, "Coupling a Single Trapped Atom to a Nanoscale Optical Cavity." Science, 340, 1202–1205 (2013).

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Date submitted: 01 Feb 2014

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