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Experimental Cluster State Quantum Computation PHILIP WALTHER, University of Vienna, Institute of Experimental Physics, Prof. Zeilinger, A, KEVIN RESCH, University of Vienna, Institute of Experimental Physics, Prof. Zeilinger, TERRY RUDOLPH, QOLS, Blackett Laboratory, Imperial College London, London SW7 2BW, UK, EMANUEL SCHENCK, University of Vienna, Institute of Experimental Physics, Prof. Zeilinger, HARALD WEINFURTER, Department of Physics, Ludwig-Maximilian-University, Munich, Germany, VLATKO VEDRAL, The School of Physics and Astronomy, University of Leeds, Leeds, LS2 9JT, UK, MARKUS ASPELMEYER, University of Vienna, Institute of Experimental Physics, Prof. Zeilinger, ANTON ZEILINGER, University of Vienna, Institute of Experimental Physics — Standard quantum computation is based on a universal set of unitary quantum logic gates which process qubits. In contrast to the standard quantum model, Raussendorf and Briegel proposed the one-way quantum computer, based on a highly-entangled cluster state, which is entirely different. We have experimentally realized four-qubit cluster states encoded into the polarization state of four photons. We fully characterize the quantum state by implementing the first experimental four-qubit quantum state tomography. Using this cluster state we demonstrate the feasibility of one-way quantum computing through a universal set of one- and two-qubit operations. Finally, our implementation of Grover's search algorithm demonstrates that one-way quantum computation is ideally suited for such tasks.

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