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Distinguishing Information Scrambling from Decoherence in a Trapped Ion Quantum Simulator T. SCHUSTER, University of California, Berkeley, K. A. LANDSMAN, C. FIGGATT, N. M. LINKE, Joint Quantum Institute, University of Maryland, College Park, B. YOSHIDA, Perimeter Institute for Theoretical Physics, N. Y. YAO, University of California, Berkeley, C. MONROE, Joint Quantum Institute, University of Maryland, College Park — The dynamics of a strongly interacting many-body system causes the scrambling of quantum information, wherein local information becomes "hidden" in non-local observables. Recently, a powerful theoretical proxy to diagnose scrambling has emerged in the form of out-of-time-ordered correlation functions (OTOCs). However, the direct and unambiguous experimental measurement of scrambling via such OTOCs remains an essential challenge. This challenge can be summarized as follows: for a generic interacting system, the scrambling of quantum information will cause OTOCs to decay to zero. However, both decoherence and imperfect experimental controls (e.g. time reversal) will *also* cause OTOCs to decay to zero. Inspired by the Hayden-Preskill variant of the black hole information problem, we describe a quantum-teleportation-based scheme which explicitly detects both the "erroneous decay" of OTOCs (from noise and decoherence) as well as the desired decay due to information scram bling. We present the experimental realization of this scheme on a 7-qubit trapped ion quantum computer. The scrambling operation is realized via a digital 3-qubit quantum gate, and teleportation fidelities of up to 80% are achieved enabling us to bound the true scrambling induced decay of the OTOC.

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