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**Measuring Entanglement Spectrum via Density Matrix Exponentiation** GUANYU ZHU, ALIREZA SEIF, Joint Quantum Institute, University of Maryland, College Park, Maryland, USA, HANNES PICHLER, PETER ZOLLER, Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, Innsbruck, Austria, MOHAMMAD HAFEZI, Joint Quantum Institute, University of Maryland, College Park, Maryland, USA — Entanglement spectrum (ES), the eigenvalues of the reduced density matrix of a subsystem, serves as a powerful theoretical tool to study many-body systems. For example, the gap and degeneracies of the entanglement spectrum have been used to identify various topological phases. However, the usefulness of such a concept in real experiments has been debated, since it is believed that obtaining the ES requires full state tomography, at a cost which exponentially grows with the systems size. Inspired by a recent density matrix exponentiation technique, we propose a scheme to measure ES by evolving the system with a Hamiltonian that is the subsystem's own reduced density matrix. Such a time evolution can be induced by an ancilla photon that is coupled to multiple qubits at the same time. The phase associated with the time evolution can be detected and converted into ES through either a digital or an analogue scheme. The digital scheme involves a modified quantum phase estimation algorithm based on random time evolution, while the analogue scheme is in the spirit of Ramsey interferometry. Both schemes are not limited by the size of the system, and are especially sensitive to the gap and degeneracies. We also discuss the implementation in cavity/circuit-QED and ion trap systems.

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