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Using time reversal to detect entanglement and spreading of quantum information[1]

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Characterizing and understanding the states of interacting quantum systems and their non-equilibrium dynamics is the goal of quantum simulation. For this it is crucial to find experimentally feasible means for quantifying how entanglement and correlation build up and spread. The ability of analog quantum simulators to reverse the unitary dynamics of quantum many-body systems provides new tools in this quest. One such tool is the multiple-quantum coherence (MQC) spectrum previously used in NMR spectroscopy which can now be studied in so far inaccessible parameter regimes near zero temperature in highly controllable environments. I present recent progress in relating the MQC spectrum to established entanglement witnesses such as quantum Fisher information. Recognizing the MQC as out-of-time-order correlation functions, which quantify the spreading, or scrambling, of quantum information, allows us to establish a connection between these quantities and multi-partite entanglement. I will show recent experimental results obtained with a trapped ion quantum simulator and a spinor BEC illustrating the power of time reversal protocols.

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