JOURNAL CLUB: Observation of quantum information collapse-and-revival in a strongly-interacting Rydberg atom array

ROXANA WEDOWSKI

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Blue Lecture Room

Interactions of isolated quantum many-body systems typically scramble local information into the entire system and make it unrecoverable1-5 . Ergodicity-breaking systems possess the potential to exhibit fundamentally different information scrambling dynamics beyond this paradigm. For many-body localized systems with strong ergod icity breaking6-8 , local transport vanishes and information scrambles logarithmically slowly9 . Whereas in Rydberg atom arrays, local qubit flips induce dynamical retardation on surround ing qubits through the Rydberg blockade effect, giving rise to quantum many-body scars that weakly break ergodicity10-12, and resulting in the predicted unconventional quantum information spreading behaviours13. Here, we present the first measurements of out-of-time-ordered corre lators and Holevo information in a Rydberg atom array, enabling us to precisely track quantum information scrambling and transport dynamics. By leveraging these tools, we observe a novel spatio-temporal collapse-and-revival behaviour of quantum information, which differs from both typical chaotic and many-body localized systems. Our experiment sheds light on the unique in formation dynamics in many-body systems with kinetic constraints, and demonstrates an effective digital-analogue approach to coherently reverse time evolution and steer information propagation in near-term quantum devices.

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