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Interference, topology, and new Hilbert-space routes to quantum non-ergodicity

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A central challenge in nonequilibrium quantum physics is to understand why certain many-body systems fail to thermalize even in the absence of disorder or integrability. In this talk, I will outline a different perspective in which non-ergodicity is governed by hidden geometric structures in Hilbert space rather than by conventional real-space mechanisms. This viewpoint leads to the concept of interference-caged quantum many-body scars (ICQMBS), where exact many-body destructive interference confines eigenstates to small regions of the Fock-space graph. Remarkably, interference zeros and graph automorphisms emerge as universal organizing principles, revealing a class of topological ICQMBS whose robustness originates from local Fock-space topology rather than symmetries or constraints. This framework not only explains diverse non-ergodic phenomena from one-dimensional systems to two-dimensional gauge models but also provides new tools for systematically identifying them. In addition to recent advances of using Fock-space graph to explore quantum ergodicity breaking, I will also summarize the recent applications of caged states in different contexts.

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