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Entanglement dynamics and chaos in systems with collective and long-range interactions

It is widely recognized that entanglement generation and dynamical chaos are intimately related in semiclassical models. In this talk I will describe a unifying framework which directly connects the bipartite and multipartite entanglement growth to the quantifiers of classical and quantum chaos. In the semiclassical regime, the dynamics of the von Neumann entanglement entropy, the spin squeezing, the quantum Fisher information and the out-of-time-order square commutator are governed by the divergence of nearby phase-space trajectories via the local Lyapunov spectrum. This constitutes the underlying mechanism for the counterintuitive slow (logarithmic) growth of entanglement in quantum spin systems with slowly-decaying interactions, shown by several numerical simulations. The standard quasiparticle contribution is shown to get suppressed as the interaction range is sufficiently increased. All our analytical results agree with numerical computations, both for two paradigmatic models of quantum chaos (the Dicke model and the kicked top) and for the quantum Ising chains with long-range couplings.

The talk will be based on the following references:

1. Origin of the slow growth of entanglement entropy in long-range interacting spin systems, A Lerose, S Pappalardi - Physical Review Research, 2020
2. Bridging entanglement dynamics and chaos in semiclassical systems, A Lerose, S Pappalardi - arXiv preprint arXiv:2005.03670, 2020

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