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From integrability to chaos in quantum Liouvillians

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Abstract:

The dynamics of open quantum systems can be expressed through a Liouvillian, which describes the non-unitary time-evolution of the density matrix. In the Markovian approximation, the Liouville equation can be expressed as a Lindblad master equation, with a unitary part that includes the Hamiltonian and some jump operators representing dephasing and relaxation. The Liouvillian is then a linear operator but is non-Hermitian. The dynamics of the system can be represented by its complex eigenvalues and corresponding eigenstates. We present a family of integrable Liouvillians for spin chains with a complex structure of the jump operators. Making use of this new region of integrability, we study the transition to chaos adding integrability-breaking terms to the Liouvillian. Generalizing the spectral statistics used for studying quantum chaos in closed systems, the transition is characterized by the statistical properties of the complex eigenvalues of the Liouvillian operator. In particular, we use the nearest neighbor spacing distribution and the ratios between eigenvalue distances.