Diagnosing chaos in open quantum systems and isolated many-body systems

Jisha C[1], Ravi Prakash[2]

Department of Physics, Motilal Nehru National Institute of Technology Allahabad - Prayagraj-211004, India

Email: jisha.2021rph03@mnnit.ac.in

Abstract

Random Matrix Theory (RMT) is a useful tool to study statistical properties of chaotic and non-integrable quantum systems. Quantum chaotic systems with one-dimensional spectra follow spectral correlations of orthogonal (OE), unitary (UE), or symplectic ensembles (SE) of random matrices depending on their invariance under time reversal and rotation.However, open quantum systems are studied using non-Hermitian and non-unitary ensembles whose eigenvalues are distributed in the two dimensional complex plane.Based on the symmetry of matrix elements,we study ensemble of complex symmetric, complex asymmetric (Ginibre), and self-dual matrices of complex quaternions.We show that the fluctuation statistics of these ensembles are universal and quantum chaotic systems belonging to OE, UE,and SE in the presence of a dissipative environment show similar spectral fluctuations. We study the short range correlations using spacing distributions and long range correlations using number variance.We develop a mechanism to unfold a spectra with non-uniform density at a non-local scale and also evaluate the number variance.We find that both short-range and long-range correlations are universal. We verify all our findings on a prototype model of chaos known as quantum kicked top in a dissipative environment.

We also present some interesting results from the study of chaos in quantum many-body systems.We study out-of-time-ordered correlators (OTOC) for diagnosing chaos and information scrambling in disordered quantum spin chains.While the initial rate of change of OTOCs are algebraic for both integrable and chaotic systems, the late scrambling regimes (approach-to-saturation phase) are universal and can be used to distinguish between integrable and chaotic systems. We verify our findings on the random field Heisenberg XXZ model.