

Silvia Pappalardi: The Eigenstate Thermalization Hypothesis and Free Probability

The Eigenstate-Thermalization-Hypothesis (ETH) has been established as the general framework to understand quantum statistical mechanics. Only recently has attention been paid to so-called general ETH, which accounts for higher-order correlations among matrix elements. In this talk, I will present the close relation between this perspective on ETH and Free Probability theory, as applied to a thermal ensemble or an energy shell. This mathematical framework allows one to reduce in a straightforward way higher-order correlation functions to a decomposition given by minimal blocks, identified as free cumulants, for which we give an explicit formula. I will illustrate examples on two classes of local non-integrable (chaotic) quantum many-body systems: spin chain Hamiltonians and Floquet brickwork unitary circuits. The results show that the non-trivial frequency dependence of free cumulants encodes the physical properties of local many-body systems and distinguishes them from structureless, rotationally invariant ensembles of random matrices. The present results uncover a direct connection between the Eigenstate Thermalization Hypothesis and the structure of Free Probability, widening considerably the latter's scope and highlighting its relevance to quantum thermalization.