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The eigenstate thermalization hypothesis and free probability

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The eigenstate thermalization hypothesis (ETH) was developed to explain the mechanism by which "chaotic" systems reach thermal equilibrium from a generic state. ETH is an ansatz for the matrix elements of physical operators in the basis of the Hamiltonian, and since its postulation, numerous studies have characterized these quantities in increasingly fine detail, providing a solid framework for understanding the (thermo)dynamics of quantum many-body systems. ETH can be viewed as a generalisation of random matrix theory and, in fact, within this ansatz matrix elements are modeled as random variables.
In our work, we have generalized the ETH ansatz in order to take into account correlations between matrix elements which are essential to describe high-order correlation functions. By analogy with the theory of random matrices, one can assume a certain hierarchy between these correlations and show how this generalized ansatz underlies a relationship between ETH and free probability. This relationship allowed us to unveil a particular structure of the time-dependent correlation functions in thermal equilibrium in terms of free cumulants.

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