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A Minimal Model for testing the Eigenstate Thermalization Hypothesis

The Eigenstate Thermalization Hypothesis (ETH) provides a foundational framework for understanding thermalization in quantum ergodic systems and, with appropriate generalizations, for characterizing equilibration in integrable models. However, numerical verification of ETH has traditionally relied on exact diagonalization (ED), which severely limits accessible system sizes.

In this work, we study an integrable model rooted in the integrability structure of Conformal Field Theories, where the matrix elements of a broad class of observables are known exactly. This allows us to verify ETH predictions both analytically and numerically for significantly larger system sizes than those attainable via ED.

Our primary result reveals that, in the thermodynamic limit, the structure of matrix elements non-trivially depends on the fluctuation scale of the ensemble from which the states are sampled. Crucially, agreement with the ETH is observed only for a specific regime of ensemble fluctuations, highlighting a subtle dependence of the ETH validity on the ensemble properties.

Our findings suggest a refined perspective on the ETH hypothesis and offer a new path for studying it beyond current numerical constraints.

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