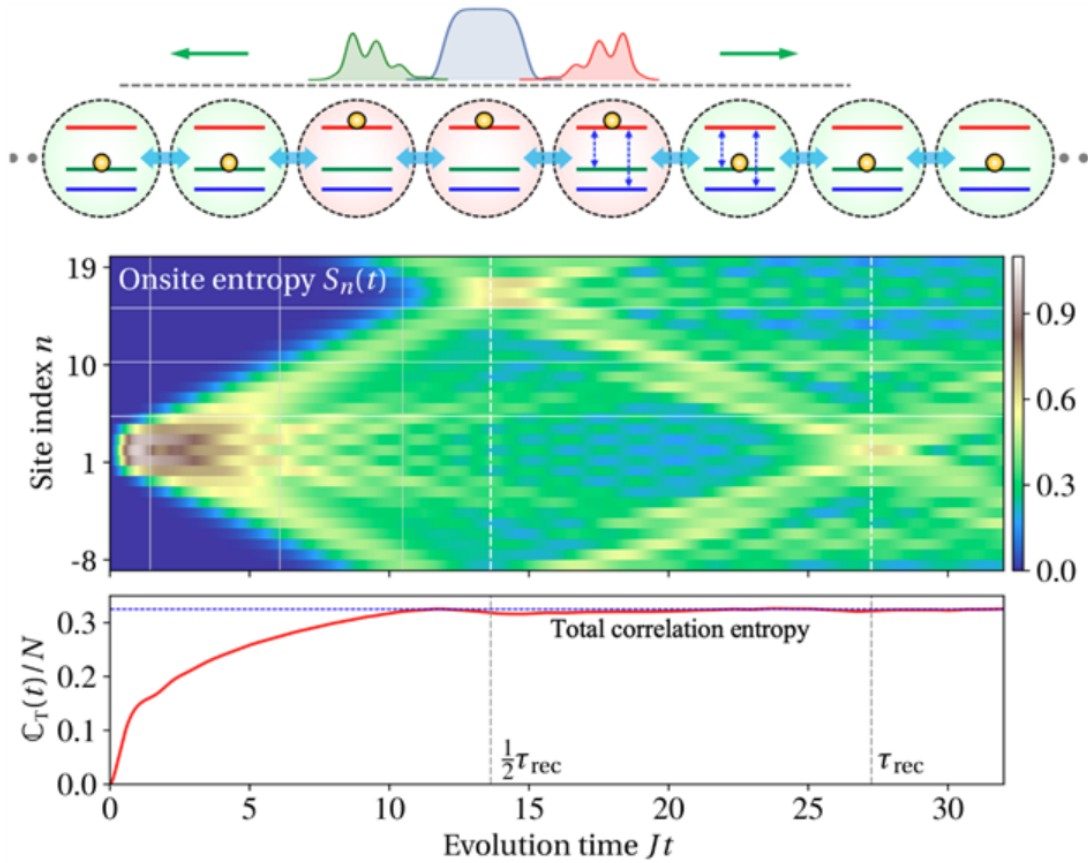


The correlational entropy production and the macroscopic irreversibility problem

Sheng-Wen Li¹

¹Beijing Institute Of Technology, Beijing, China

Isolated quantum systems follow the reversible unitary evolution, which seems inconsistent with the irreversibility in macroscopic thermodynamics. We notice that such a paradox can be reconciled when focusing on the local relaxation process. Here we study the exact dynamics in an isolated system, which contains a finite number of three-level systems. When focusing on the dynamics of local states and local observables, irreversible behaviors naturally appear. Though the entropy of the full many-body state always keeps unchanged, the "total correlation entropy" of this system exhibits an irreversibly increasing behavior, which well corresponds to the macroscopic entropy growth. Moreover, our variation analysis shows that, the total correlation entropy would achieve its theoretical maximum if each site is in a "generalized one-body Boltzmann state", which is not solely determined by the energy but also depends on the onsite pseudo-spins, and such a theoretical correlation maximum is highly coincident with the exact time evolution. In this sense, the total correlation entropy well serves as a generalized indicator for the dynamical irreversibility of the nonequilibrium relaxation in this isolated system. More generally, for open systems coupled with some heat baths, such total correlation entropy growth well returns the irreversible entropy production in the standard thermodynamics.



$$\bar{\rho}_n \sim \exp(-\beta_E \hat{H}_n - \beta_S \hat{S}_n^z)$$