Large-deviation analysis of rare resonances for the Many-Body localization transition

Marco Tarzia

A central theoretical issue at the core of the current research on many-body localization (MBL) consists in characterizing the statistics of rare long-range resonances in many-body eigenstates. This is of paramount importance to understand: (i) the critical properties of the MBL transition and the mechanism for its destabilization through quantum avalanches; (ii) the unusual transport and anomalously slow out-of-equilibrium relaxation when the transition is approached from the metallic side. In order to study and characterize such long-range rare resonances, we develop a large-deviations approach based on an analogy with the physics of directed polymers in random media, and in particular with their freezing glass transition on infinite-dimensional graphs. The basic idea is to enlarge the parameter space by adding an auxiliary parameter (which plays the role of the inverse temperature in the directed polymer formulation) which allows us to fine-tune the effect of anomalously large outliers in the far-tails of the probability distributions of the transmission amplitudes between far-away many-body configurations in the Hilbert space. We apply this approach to the study of a class of disordered quantum spin chains in a transverse field. This analysis shows the existence of a broad disorder range in which rare, long-distance resonances, that in finite-size systems may only form for a few specific realizations of the disorder and a few specific choice of the random initial state, are expected to destabilize the MBL phase in the thermodynamic limit, while the genuine MBL transition is shifted to much larger values of the disorder than originally thought.