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Dynamic phase transitions and anomalous critical behavior of a purely quantum random energy model

Random energy model can be viewed as the toy and somewhat unphysical model of a glass. Recently the interest to the dynamics of this model was revived due to its potential importance to the problem of the efficient quantum searches. The thermodynamics of this model is completely trivial: it displays the transition from glassy low temperature phase where it is dominated by a single low energy state to the paramagnetic high temperature phase. The dynamical properties quantum version of this model turns out to be much less trivial and displays a number of phase transitions. In this work we show that in a wide parameter range the dynamics of this model is equivalent to that of Porter Thomas random matrix model and show all properties associated with non-ergodic states, including anomalous power-law dependences on the system size and ergodic to non-ergodic and non-ergodic to fully localized transitions. In the whole intermediate non-ergodic phase the dynamics of the model is characterized by anomalous scaling exponents.