Many-body localization in the Sherrington-Kirkpatrick model

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Abstract (Century Gothic 11)

The Sherrington-Kirkpatrick (SK) model, the archetypal model for spin glasses, has been extensively studied for more than 50 years [1]. In the context of optimization problems, it represents one of the most difficult paradigmatic optimization problems, the MAXCUT problem.

Its quantum extension, the transverse field SK model (TFSK model) is therefore a paradigmatic model for the Quantum Adiabatic Optimization Approach (QAOA).

The TFSK model, however, represents an extremely hard problem in this regard, since it displays a paramagnet to spin glass transition, and the presence of this glassy phase represents a major obstacle from the perspective of QAOA. Here we explore this quantum glass model in terms of many-body localization (MBL). Quite interestingly, in Ref.~[2] a transition the MBL has been explored, however, the nature of the localization-delocalization and its relation to the glassy phase is a matter of debate [2].

We performed extensive numerical simulations of the SK model at different transverse field strengths to extract various MBL-indicators, such as inverse participation ratio, Shannon entropy, and level spacing ratio, which we studied by means of finite-size scaling analysis. Our numerical and analytical analysis suggest the presence of an MBL transition as a function of the transverse field at all energy densities. However, this transition is clearly different from the spin-glass transition, in contrast to the findings of Ref.~[2]. In the MBL phase, states do not seem to be exponentially localized, rather, our data suggest the presence of power-law MBL.

References

[1] Marc Mezard, Giorgio Parisi, Miguel Angel Virasoro, Spin Glass Theory And Beyond: An Introduction To The Replica Method And Its Applications (1987)

[2] Mukherjee, Sudip and Nag, Sabyasachi and Garg, Arti, Phys. Rev. B 97, 144202 (2018)

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Figures

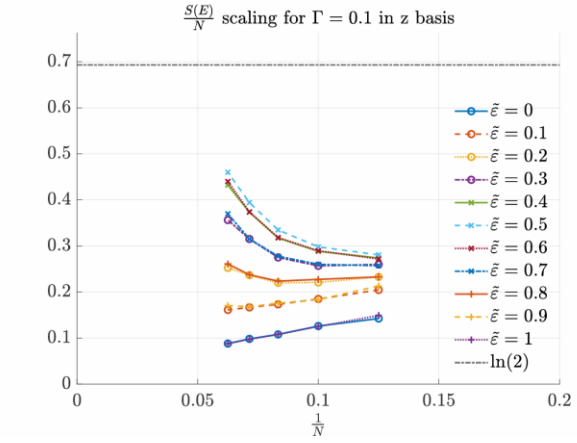

Figure 1: Configuration-averaged Shannon-entropy density of the SK model at different system sizes at transverse field Gamma = 0.1J. Average was taken over 600 configurations for N = 8, 10, 12, 14 and 100 configurations for N = 16. A finite value at the TDL corresponds to power-law localization.