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Quantum Lyapunov spectrum and two-point correlation functions of the Sachdev-Ye-Kitaev model

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Abstract:

Recent progress in the study of the Sachdev-Ye-Kitaev (SYK) model and its variants have attracted renewed attention in systems with quantum chaotic dynamics. Experimental realization of the SYK model has been proposed in various setups such as atoms in optical lattices and a thin film superconductor on the surface of a three-dimensional topological insulator. [1][2] Such experiments are expected to reveal quantum aspects of black holes, which are maximally chaotic systems in nature, according to the holographic principle.

We define a quantum generalization [3] of the spectrum of finite-time classical Lyapunov exponents, to characterize quantum many-body chaos. [4] We study the statistical features of this quantum Lyapunov spectrum and find random matrix behavior, which is lost when the model is deformed away from chaos towards integrability [5] by a random two-fermion term. For the XXZ spin chain with a random longitudinal field, we also find the random matrix behavior for non-localized regime, which is lost as many-body localization occurs. Furthermore, we discuss the possibility of using a simpler quantity, the singular values of two-point correlation matrices, for characterizing quantum many-body chaos. [6]

References

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[2] M. Franz and M. Rozali, "Mimicking black hole event horizons in atomic and solid-state systems", Nature Reviews Materials **3**, 491 (2018).

[3] H. Gharibyan, M. Hanada, B. Swingle, and M. Tezuka, "Quantum Lyapunov Spectrum", arXiv:1809.01671.

[4] M. Hanada, H. Shimada, and M. Tezuka, "Universality in Chaos: Lyapunov Spectrum and Random Matrix Theory", Phys. Rev. E **97**, 022224 (2018).

[5] A. M. Garcia-Garcia, B. Loureiro, A. Romero-Bermudez, and M. Tezuka, "Chaotic-Integrable Transition in the Sachdev-Ye-Kitaev Model", Phys. Rev. Lett. **120**, 241603 (2018).

[6] H. Gharibyan, M. Hanada, B. Swingle, and M. Tezuka, in preparation.

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