Quantum Lyapunov spectrum and two-point correlation spectrum

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Recent progress in the study of the Sachdev-Ye-Kitaev (SYK) model and its variants have attracted renewed attention in the characterization of quantum chaotic dynamics. Experimental realization of the SYK model has been proposed in various atomic and solid condensed matter setups. [1][2] Such experiments would reveal quantum aspects of black holes, which are maximally chaotic systems in nature, according to the holographic principle.

In order to characterize quantum many-body chaos, we define a simple quantum generalization [3] of the spectrum of finite-time classical Lyapunov exponents. [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, which is one of the prototypical models for many-body localization, 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 even simpler quantities such as the singular values of two-point correlation matrices for characterizing quantum many-body chaos. [6]

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