Family of Sachdev-Ye-Kitaev models motivated by experimental considerations

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(Dated: May 25, 2018)

Several condensed-matter platforms have been proposed recently to realize the Sachdev-Ye-Kitaev (SYK) model in their low-energy limit. In these proposed realizations, the characteristic SYK behavior is expected to occur under certain assumptions about the underlying physical system that (i) render all bilinear terms small compared to four-fermion interactions and (ii) ensure that the coupling constants are approximately all-to-all and independent random variables. In this work we explore, both analytically and numerically, the family of models that arises when we relax these assumptions in ways motivated by real physical systems. By relaxing (i) and allowing large bilinear terms, we obtain a novel, exactly-solvable cousin of the SYK_2 model. It exhibits two distinct phases separated by a quantum phase transition characterized by a power-law, $\sim |\omega|^{-1/3}$ scaling of the low-energy spectral density, despite being a non-interacting model. By relaxing (ii), we obtain close relatives of the SYK_4 model which exhibit interesting behaviors, including a chaotic non-Fermi liquid phase with continuously varying fermion scaling dimension, and a phase transition to a disordered Fermi liquid as a function of interaction range and disorder length scale.

arXiv:1803.07197