Reaching SYK physics by shaking the Hubbard model

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Abstract

The Sachdev-Ye-Kitaev (SYK) model [1,2] has attracted widespread attention because of its relevance to many diverse areas of physics, ranging from high temperature superconductivity to black holes and quantum chaos. The model is, however, extremely challenging to realize experimentally. In this work, I will show how a particular form of Floquet engineering, termed "kinetic driving", effectively eliminates single-particle hopping processes and creates quasi-random all-to-all interactions when applied to models of Hubbard type. For the specific case of the Bose-Hubbard model, we have demonstrated [3] that the kinetically-driven system indeed reproduces SYK physics by first studying its spectral statistics, and then by comparing the spectral form factors (SFFs) and out-of-time ordered correlation functions (OTOCs) of the two models. Our findings indicate that a cold-atom realization of kinetic driving — achieved by means of the high-frequency modulation of hopping amplitudes in an optical lattice — offers a practical and accurate platform for quantum simulation of the SYK model.

References

[1] Subir Sachdev and Jinwu Ye, Phys. Rev. Lett. (1993) 3339.
[2] Alexei Kitaev, talks at KITP, April 7, 2015 and May 27, 201, available online at http://online.kitp.ucsb.edu/online/entangled15/kitaev and http://online.kitp.ucsb.edu/online/entangled15/kitaev2
[3] Charles Creffield, Fernando Sols, Marco Schirò, and Nathan Goldman, arXiv:2512.02755.

Figures

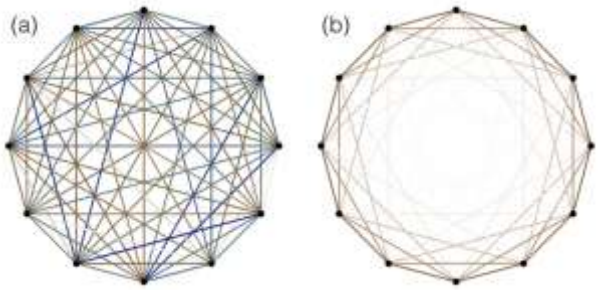

Figure 1: Schematic representation of the site-to-site hopping amplitudes in the (a) SYK model and (b) kinetically-driven Hubbard model. In the SYK model the hoppings connect each site to every other site with a random tunneling amplitude. In the driven model the hoppings can still be long-ranged, but their amplitudes drop with distance. Nonetheless the driven Hubbard model is able to reproduce SYK physics with excellent accuracy.