凝縮系物理学ゼミナール

Condensed Matter Theory Seminar Date: 13:30-15:00, Wednesday, 18 June 2025

Title: Introduction to entanglement in the Sachdev-Ye-Kitaev model at Large-N

Speaker: Dr. Indrasen Ghosh (Indian Institute of Technology Kharagpur) Language: English

Abstract:

The Sachdev-Ye-Kitaev (SYK) [1-2] model serves as a key solvable paradigm for studying quantum chaos, holography, and entanglement dynamics. We present an introductory analysis of the SYK model and its variants, employing numerical [3] exact diagonalization for finite-N systems and (primarily) analytical large-N techniques.

The large-N formalism is developed, leading to the derivation of the effective action and saddle-point equations, accurately capturing thermodynamic properties like the non-zero residual entropy.

We investigate the second R envi entropy using both exact diagonalization and the large-N replica trick, comparing results and examining thermal versus entanglement contributions across different temperatures and subsystem sizes. Furthermore, we study entanglement dynamics in a coupled SYK4 system.

Applying the replica method to this setup reveals the existence of distinct saddlepoint solutions, including replica-diagonal configurations and, significantly, replica wormholes where correlations form between initially disconnected replica contours. The competition between these saddles can lead to phase transitions in the R[']enyi entropy dynamics. This explicit realization of replica wormholes [4] in a controlled setting provides valuable insights into entanglement structure in chaotic systems and strengthens connections to gravitational path integrals and the black hole information paradox.

References:

- S. Sachdev and J.-w. Ye, "Gapless spin fluid ground state in a random, quantum Heisenberg magnet," Phys. Rev. Lett. 70 (1993) 3339
- [2] A. Kitaev, "A simple model of quantum holography." http://online.kitp.ucsb.edu/online/entangled15/kitaev/,http: //online.kitp.ucsb.edu/online/entangled15/kitaev2/. Talks at KITP, April 7, 2015 and May 27, 2015.
- [3] J. Maldacena and D. Stanford, "Remarks on the Sachdev-Ye-Kitaev model," Phys. Rev. D94 (2016) 106002.

[4] G. Penington, S. H. Shenker, D. Stanford, and Z. Yang, (2019).