北京大学量子材料科学中心

International Center for Quantum Materials, PKU

Seminar

Quantum Loop Topography for Machine learning
-- on topological phase, phase transitions, and beyond

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Time: 4:00pm, Jan. 15, 2018 (Monday)

时间：2018年01月15日 （周一）下午4:00

Venue: Room W563, Physics building, Peking University

地点：北京大学物理楼，西563会议室

Abstract

Despite the rapidly growing interest in harnessing machine learning in the study of quantum many-body systems, there has been little success in training neural networks to identify quantum phases. The key challenge is in efficiently extracting essential information from the many-body Hamiltonian or wave function and passing the information to a neural network. When targeting topological phases, this task becomes particularly challenging as topological phases are defined in terms of non-local properties. Here we introduce Quantum Loop Topography: a procedure of constructing a multi-dimensional image containing essential information on the phase of the corresponding "sample" Hamiltonian or wave function, by evaluating relevant operators at independent Monte Carlo steps. Such operators take semi-local loop structures and are determined by either the characteristic responses or the quasi-particle statistics of the targeted phases. Feeding the Quantum Loop Topography into a fully-connected neural network with a single hidden layer, we demonstrate that the architecture can be effectively trained to distinguish Chern insulator and fractional Chern insulator, as well as Z2 quantum spin liquid, with high efficiency and fidelity. I'll also summarize recent progress on tackling other quantum phases, reverse engineering neural networks, and connections with quantum entanglement. Given the versatility of the procedure that can handle different lattice geometries, disorder, interaction and even degeneracy our work paves the route towards powerful applications of machine learning in the study of topological quantum matters, phase transitions, and beyond.

References: Yi Zhang, and Eun-Ah Kim, Phys. Rev. Lett. **118**, 216401 (2017) [Editors' Suggestion and Viewpoint]; Yi Zhang, Roger G. Melko, and Eun-Ah Kim, Phys. Rev. B **96**, 245119 (2017).

About the speaker

Zhang, Yi is a theoretical condensed matter physics focusing on emergent phenomena and novel approaches in strongly-correlated systems. He obtained his B.S. in Physics at Fudan University. During his Ph.D. study at UC Berkeley under the supervision of Prof. Ashvin Vishwanath, he received the annual Jackson C. Woo award for outstanding condensed matter research. He then moved to Stanford University as a SITP postdoctoral fellow. Most recently, he moved to Cornell University as the Bethe fellow. In addition to collaborating with experimentalists on topological materials and magneto-transports, Yi Zhang has contributed to the introduction of various techniques using novel perspectives to understand strongly correlated systems, such as machine learning and quantum entanglement, as well as models and properties of topological phases, quantum spin liquids, and non-Fermi liquids.