Seminar

Topological interference effect in Anderson transition and Superfluid systems

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Time: 10:00 am, June 15, 2026 (Monday)

时间：2026年6月15日（周一）上午10:00

Venue: Room w563, Physics building, Peking University

地点：北京大学物理楼，西563会议室

Abstract

Topology plays a crucial role in the emergent phases and phase transitions in physics. Pioneering examples are quantum Hall phases and low-dimensional quantum magnets, whose key features are universally explained by the nonlinear sigma model with topological terms. Phase transitions in the sigma models are driven by the spatial (space-time) proliferation of topological defects, alongside conventional spin-wave fluctuations. The topological terms interfere with the defect proliferation by conferring phase factors upon the defect configurations, causing what we called `topological interference effect'. In this talk, I will discuss two examples of this. In the first example, I will show that the Anderson transition in chiral symmetry classes becomes two-step phase transition in the presence of one-dimensional (1D) weak topology, and that a new thermodynamic phase—which we term the quasi-localized phase—universally appears between the metallic and Anderson-localized phases [1,2,3]. In the quasi-localized phase, the localization length along the spatial direction associated with the 1D weak topology (the "topological direction") diverges, while the localization lengths along the other directions remain finite. From a unification theory of the Anderson transition of Hermitian and non-Hermitian systems [4], we expect that the proposed quasi-localized phase has broader applications to wave localization phenomena in open physical systems with steady flows.

In the second example, I will discuss how the topological interference effect underlies an emergent Bose-glass-analog phase in superfluid systems [5]. The (d+1)-dimensional U(1) sigma model with a temporal Berry phase serves as a generic effective theory for the phase-fluctuation-driven superfluid transition in d dimension, in which the superfluid U(1) phase fluctuates in both space and time, while the superfluid amplitude is constrained to a finite value by some physical mechanisms. The temporal Berry phase term originates from the commutation relation between the superfluid amplitude and the U(1) phase. By developing a renormalization group program analogous to the BKT theory, I will elucidate how the temporal Berry phase term induces a polarization of vortex lines along the time direction in the (2+1)-dimensional model, leading to the universal emergence of a Bose-glass-analog phase adjacent to the ordered phase. Namely, as the polarized vortex lines destroy only the spatial correlations of the U(1) phase, temporal phase coherence still persists under the proliferation of the vortex lines, and only the spatial U(1) phase correlations become short-ranged.

[1] Z. Xiao, et. al., Phys. Rev. Lett. **131**, 056301 (2023).
[2] P. Zhao, et.al. Phys. Rev. Lett. **133**, 22660 (2024).
[3] P. Zhao, et. al., Phys. Rev. B **112**, 174203 (2025)
[4] X. Luo, et. al., Phys. Rev. Res. **4,** L022035 (2022)
[5] R. Shindou, et.al., arXiv:2603.09422.

About the speaker

Dr. Ryuichi Shindou is a theory faculty in School of Physics in Peking University. He is broadly working on theories of emergent phases and phase transitions in physics, quantum transport and wave localization phenomena, magnetism, and correlated electron systems.