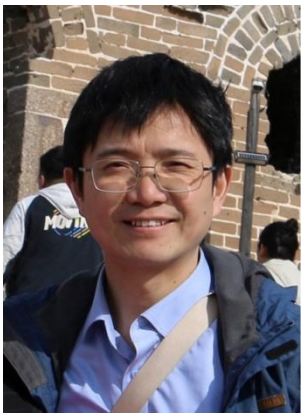
北京大学量子材料科学中心

International Center for Quantum Materials, PKU

Lecture Series

Lectures on Groups and their Representations: from Quasiparticles to Quantum Matter



Prof. Zheng-Xin Liu

Renmin University of China

Venue: Room w563, Physics building, Peking University

地点：北京大学物理楼，西563会议室

Abstract

Symmetries play important roles in condensed matter physics. For instance, space groups are used to distinguish 230 crystal structures, and projective representations (Reps) of point groups can classify quasiparticles in semimetals and describe fractionalized anyons in topologically ordered phases. In this series of lectures, we will focus on the symmetry groups of crystals having magnetic order and/or superconducting order. After introducing projective Reps and the cohomological classes of various groups, we will discuss their applications in semimetals, symmetry protected topological (SPT) phases, and quantum spin liquids (QSL).

Lecture 1	Jun 9 (10am-12pm)	Groups and their representations, induced representation; Methods to obtain irreducible representations; k.p theory and physical responses of quasiparticles;
Lecture 2	Jun10 (10am-12pm)	Group structure for general anti-unitary groups; Projective Reps, factor systems, cocycles and invariants; 1D Symmetry Protected Topological (SPT) phases;
Lecture 3	Jun12 (10am-12pm)	2D and higher dimensional SPT phases; SPT and anomalous edge excitations; Symmetry fractionalization of anyons in topological states;
Lecture 4	Jun16 (10am-12pm)	Symmetry of magnetically ordered crystals, MSG and SSG; Symmetry invariants and quasiparticle types; Physical response and detection of symmetry invariants;
Lecture 5	Jun18 (10am-12pm)	Symmetry group for BdG systems (mean fields for SC and QSL); Internal spin-charge symmetry and the SO(4) group; Bulk zero modes and symmetry conditions;
Lecture 6	Jun20 (10am-12pm)	Spin-charge space groups: “entanglement” of spin, charge and lattice; Extension of groups: normalizer group, automorphism and cocycles; Outlook of generalized symmetries.

About the lecturer

Zheng-Xin Liu obtained his Ph.D in the Hong Kong University of Science and Technology in 2010. Then he worked in IAS of Tsinghua University for five years and joined Renmin University of China in 2015, and now he is a full professor at Renmin University of China. Dr. Liu's research interest includes topological phases, quantum magnetism, superconductivity, and many-body quantum computation. With collaborators, he worked out the classification of bosonic SPT phases, proposed the existence of multi-node quantum spin liquids in Kitaev systems, and introduced symmetry invariants to characterize quasiparticles in magnetic systems.