北京大学量子材料科学中心

International Center for Quantum Materials, PKU

Seminar

From hybrid light-matter cat states to multi-gap topology

Volker Karle

University of Tokyo



Time: 3:00 pm, Nov.23, 2026 (Monday)

时间：2026年11月23日（周一）下午3:00

Venue: Room w563, Physics building, Peking University

地点：北京大学物理楼，西563会议室

Abstract

Topological physics in hybrid light–matter systems offers a promising route toward future quantum technologies. In this talk, I will discuss several examples in which strong light–matter coupling, entanglement, periodic driving, and dissipation give rise to new quantum states and dynamics. First, I will show how strong coupling between cold polar molecules and a microwave cavity produces hybrid photonic-rotational cat states protected by a Z_2 parity symmetry. These entangled light–matter states combine low decoherence with potential applications in protected bosonic encodings and can be stabilized under periodic driving even in the presence of loss. As a second example, I will show how Floquet modulation in cavity-coupled tweezer arrays tunes the effective interaction range from long to short, reshaping collective dynamics and opening pathways to strongly correlated states and novel gate protocols. Including cavity dissipation generates correlated decay channels and effective non-Hermitian dynamics, leading to many-body Hatano–Nelson-type models. Finally, I will demonstrate how graphene embedded in a circularly polarized cavity develops topological gaps through coherent light–matter coupling without heating. These gaps support unidirectional hybrid light–matter edge currents, including bright modes that persist throughout the photon ladder. Time evolution of initially dark electronic edge excitations reveals their coherent conversion into propagating chiral currents. Going beyond the single-particle picture, I will explore the emergence of correlated many-body states in cavity-coupled graphene. Using density-matrix renormalization group calculations, I will discuss the formation of many-body gaps, numerical indications of nontrivial many-body Chern topology, and the possibility of chiral collective edge excitations. These results highlight how quantized cavity fields can fundamentally reshape both the topology and correlations of electronic quantum matter.

About the speaker

Volker Karle is a theoretical physicist who studied physics and mathematics in Freiburg, Heidelberg, and Berlin before completing his PhD at the Institute of Science and Technology Austria (ISTA), near Vienna (Austria). Since 2026, he has been a JSPS Postdoctoral Fellow at the Institute for Solid State Physics (ISSP), University of Tokyo, in the group of Prof. Takashi Oka. His research focuses on quantum many-body physics, topological phases of matter, nonequilibrium quantum systems, Floquet engineering, and light–matter interactions.