

“Electrodynamics of Novel Quasiparticles in Quantum Matter ”

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Abstract

Quantum materials refer to materials systems where the underlying microscopic quantum effects manifest in macroscopic scales and defy classical descriptions. Our understanding of these complex materials begins with the exploration of “quasiparticles”, entities like fermions and bosons that are the building blocks of quantum matter. For instance, Dirac and Weyl fermions, characterized by non-trivial topology and dispersive linear bands, give rise to exotic phases of matter with protected states and anomalous response functions. The discovery of nodal-line fermions further enriches our understanding of the topological band-crossings, evolving from familiar Dirac points to lines, loops, and even cages in momentum space. Uncovering new nodal-line fermions is challenging since often the Dirac nodal-lines are dispersive, submerged within a Fermi sea, and can be gapped by spin-orbit-coupling. In this talk, I will first introduce how precise optical and magneto-optical spectroscopies can reveal the elusive nodal-line fermions. While electronic anisotropy associated with nodal-lines gives rise to greatly reduced kinetic energy along the line, experimental evidence for the correlated electronic states in nodal-metals is sparse. I will discuss the spectroscopic hallmarks of electronic correlations in topological metal ZrSiSe, and examine more exotic quasiparticles emerging from nodal-line crossings. The pronounced electronic anisotropies also create extreme photonic anisotropies, which we utilize to create various polaritons that are imaged in real space with nano-optics. These “half-light half-matter” bosonic quasiparticles facilitate seamless integration with current photonics research in strong light-matter interaction and on-chip frequency conversion. Finally, I will discuss future directions towards quantum sensing at the nanoscale, harnessing these novel quasiparticles and the quantum light-matter interaction.

Biography

Yinming Shao is currently a postdoctoral research scientist at Columbia University. He began his PhD studies in Physics at the University of California San Diego (2013-2016) and then at Columbia University (2017-2020). He received his PhD degree in Physics from Columbia University in 2020, under the supervision of Prof. Dmitri Basov. He is interested in the discovery, understanding and control of quasiparticles in quantum materials using various optical spectroscopy and nano-imaging tools.