CONDENSED MATTER SCIENCES SEMINAR

Professor Md Shafayat Hossain

UCLA

Host

Dr Luis Balicas

Title

Unconventional normal and superconducting states in a kagome metal

Friday, August 8th 31st, 2025

1st Floor – B101

15:00-16:00

Abstract

Abstract: The kagome lattice offers a unique electronic landscape characterized by flat bands and van Hove singularities—features that enhance electronic correlations and drive instabilities such as superconductivity and charge density waves. As a result, kagome systems host a rich array of emergent many-body quantum phases, some exhibiting unconventional behavior. In this talk, I will present our investigation of the kagome-lattice superconductors AV_3Sb_5 (A = K, Cs), a family of materials that have garnered significant recent attention due to the presence of chiral charge order—potentially breaking time-reversal symmetry—alongside nematicity and superconductivity with an ungapped Fermi surface sheet. First, I will describe how we probed broken symmetries in the normal state using the material's nonlinear electromagnetic response to circularly polarized light [1]. Next, I will discuss our discovery of two distinct superconducting regimes in CsV_3Sb_5, intriguingly without any clear phase transition between them [2]. These regimes exhibit sharply different characteristics: the low-temperature phase reveals a second superconducting gap and supports low-energy quasiparticles, potentially arising from a nodal gap structure. I will conclude with a discussion of the broader implications of these findings and mention our ongoing efforts to understand these kagome superconductors.

[1]. Cheng, ZJ., Hossain, M.S., Zhang, Q. *et al.* Broken symmetries associated with a Kagome chiral charge order. *Nat Commun* 16, 3782 (2025).

[2]. Hossain, M.S., Zhang, Q., Choi, E.S. *et al.* Unconventional gapping behavior in a kagome superconductor. *Nat. Phys.* 21, 556–563 (2025).

These works were done in collaboration with Prof. Luis Balicas, Dr. Eun Sang Choi, Dr. Alimamy Bangura, and Dr. David Graf at the NHMFL.

Bio: Md Shafayat Hossain is an Assistant Professor in the Department of Materials Science and Engineering at the University of California, Los Angeles (UCLA). Before joining UCLA, he was a lecturer and postdoctoral associate in the Department of Physics at Princeton University. He earned his Ph.D. in Electrical Engineering & Materials Science from Princeton, where he was a Fellow in Natural Sciences & Engineering and a University Administrative Fellow. His research uses scanning tunneling microscopy, quantum transport, and optical techniques to explore quantum materials and devices. Shafayat's work includes discovering the first room-temperature, ambient-pressure quantum state, and the experimental realization of several elusive quantum phases such as Bloch ferromagnetism, Pomeranchuk instability, hybrid topology, and topological excitonic insulators. Beyond academic work, Shafayat is passionate about science outreach. He initiated hands-on programs for visually impaired students in the East Coast area and now serves as an APS Career Mentoring Fellow.