

CONDENSED MATTER COLLOQUIUM SERIES

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The rich landscape of intertwined electronic phases in quantum materials

Quantum materials encompass a wide family of systems that display many fascinating phenomena, from high-temperature superconductivity to topological order. They stand out not only as promising candidates for new technological applications, but also as windows into the fundamental microscopic properties of interacting electrons, whose collective behavior can be very different from the behavior of an individual electron. Macroscopically, these electronic correlations are manifested by the emergence of complex phase diagrams displaying a plethora of electronic states that are not independent, but intertwined. In this talk, I will present a theoretical framework that captures the intricate interplay between electronic states of matter that may seem unrelated at first sight. Based on the concept of vestigial orders, it generalizes to the quantum realm concepts common to the description of liquid crystals. More specifically, in this approach, thermal or quantum fluctuations cause an electronically ordered state to partially melt in multiple stages, leading to the emergence of two or more intertwined phases with comparable energy scales. This framework not only sheds new light on the known phase diagrams of various quantum materials, such as iron-based superconductors, but it also provides new insights into the experimental realization of exotic states, such as a charge-4e superconducting phase in twisted bilayer graphene.

Professor Rafael Fernandes is a condensed matter physics theorist known for his contributions to the elucidation of electronic nematicity and vestigial electronic order in quantum materials. He received his Bachelor's (2003), Master's (2005) and Doctoral (2008) degrees from the University of Campinas in Brazil. His PhD work, supervised by Dr. Harry Westfahl Jr., focused on the properties of competing interactions in different types of electronic systems, such as magnetic thin films, strongly-correlated Mott insulators, and electronic liquid crystals. From 2008 to 2011, he was a postdoc at Ames National Lab and Iowa State University, working under the supervision of Prof. Joerg Schmalian primarily on the then recently discovered family of unconventional iron-based superconductors. From 2011 to 2012, he held a joint postdoctoral appointment in Columbia University and Los Alamos National Lab, where he was supervised by Prof. Andy Millis and Prof. Sasha Balatsky. Besides continuing to focus on iron-based superconductors, he also worked on superconductivity in quantum paraelectrics. In 2012, he joined the faculty at the University of Minnesota, where he became a Distinguished McKnight University Professor. In 2024, Professor Fernandes joined the Department of Physics at the University of Illinois Urbana-Champaign.

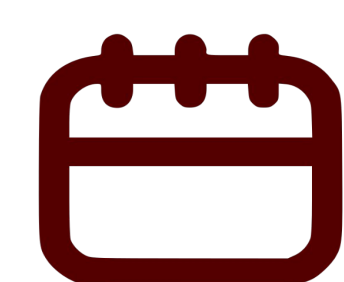
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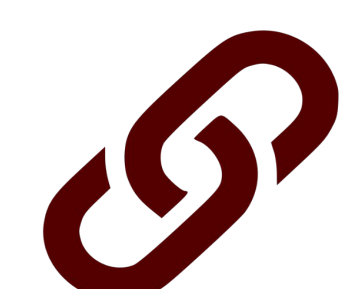


May, 27, 2025

Tuesday



19:00, (Ankara Time)



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