Title: Harnessing Multi-Electron Entanglement in Modern Quantum Materials

Abstract:
The quantum technologies of the 20th century—ranging from semiconductors to lasers—were built on an understanding of quantum mechanics at the level of individual electrons. In recent decades, however, a new frontier has emerged: the collective quantum behavior of many interacting electrons, where entanglement across large ensembles determines the emergent properties of materials. This shift has transformed our understanding of strongly correlated systems and revealed that multi-electron quantum entanglement lies at the heart of high-temperature superconductivity and other exotic phases of matter.

These insights are not only conceptually profound but also increasingly relevant for next-generation technologies. High-temperature superconductors, for example, are being explored in innovative approaches to magnetically confined fusion energy. Moreover, the theoretical frameworks developed to understand entanglement in these complex quantum materials have informed and inspired modern approaches to quantum error correction—a foundational pillar of scalable quantum computation.