Bertaut Prize

Disentangling coupled degrees of freedom in quantum materials

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A renowned quote attributed to Aristoteles states that "*the whole is greater than the sum of its parts".* While this principle has become a cornerstone in leadership and team-building strategies, it also serves as an analogy to the concept of *emergence* in quantum materials. This family of correlated condensed matter systems exhibits deeply intertwined charge, spin, orbital, and lattice degrees of freedom, their interactions giving rise to emergent macroscopic quantum effects. The effects span from unconventional superconductivity over multiferroicity to correlated spin liquid and topologically protected quantum phases. Although the signi@icance of coupled degrees of freedom in strongly correlated materials is widely acknowledged within the condensed matter community, elucidating the microscopic realization of this coupling remains challenging in many cases. In this talk I will show that a major key challenge in disentangling the contributions of various degrees of freedom in quantum materials arises from the sparse availability of microscopic probes that are appropriate for the relevant degrees of freedom, and their combination with external tuning parameters that ef@iciently affect their ground state properties. Leveraging on our recent successes in attaining microscopic interactions in different model materials, I will exemplify that contemporary neutron and x-ray scattering instrumentation, the use of unconventional external tuning parameters, state-of-the art calculations and digital competences provide an opportunity to make ef@icient progress in comprehending how emergent quantum states arise from coupled degrees of freedom.