Ph.D. Thesis

Electronic and magnetic properties of low-dimensional strongly correlated multiorbital systems

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Abstract

This thesis aims to establish the static and dynamic properties of the multiorbital Hubbard model in low dimensions. Inspired by the 123 family of iron-based ladders, the objective is to provide a global view on the intriguing properties exhibited by various low-dimensional multiorbital compounds with strong correlations.

This goal is realized by uncovering four distinct properties of the model via numerical calculations using the density-matrix renormalization group method. First, the investigation into the magnetism of a multiorbital ladder reveals a remarkable array of exotic magnetic patterns, including blocks, block spirals, and a spin-flux state. Second, through examining the interplay between the block-spiral order and superconductivity, this thesis demonstrates the emergence of topological Majorana zero modes, facilitated by an interaction-induced topological phase transition. Third, a similar transition is observed in a two-orbital Hubbard chain at half filling, leading to the emergence of the topological Haldane phase. Fourth, by investigating spectral functions, a generic feature called the Hund band is unveiled, which coexists with the familiar Hubbard bands in multiorbital spectra. These findings are presented in the form of four articles, to which the author of this thesis actively contributed.

Overall, this thesis emphasizes the wealth of exotic phenomena in low-dimensional multiorbital systems, providing motivation for further exploration and contributing to the broader understanding of multiorbital correlated physics.