PROPERTIES OF LOW-DIMENSIONAL QUANTUM SYSTEMS WITH CHARGE, SPIN, AND ORBITAL DEGREES OF FREEDOM

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Strong correlations lie at the heart of modern condensed matter physics. Experience with such systems, especially Cu-based materials, showed that the high-temperature superconductivity is closely connected to a bad-metal state and a nearby antiferromagnetic order. As such, considerable effort has been devoted to understanding the electron correlation effects and the associated magnetism. The theoretical investigations of the systems mentioned above are overwhelmingly done within the paradigmatic model of interacting fermions on a lattice, i.e., the single-band Hubbard model. In this context, the analysis of lower dimensional systems, such as chains and ladders, provided useful information to better contrast theory with the experiments. One reason is that the theoretical many-body calculations based on model Hamiltonians can be accurately performed numerically in one dimension.

On the other hand, the properties of the multi-orbital system, relevant for the Fe-based compounds (the second largest family of high-temperature superconducting materials), are much less explored. Iron-based superconductors display a variety of phases originating in the multi-orbital nature of iron itself, or to be more precise, in the competition between electronic, orbital, and spin degrees of freedom. The orbital-selective Mott phase is prominent among these novel effects, where electronic correlations cause a unique mixture of metallic and insulating behavior. This project's scientific goal and the reason for creating the research group is to investigate such novel phenomena. Especially, we will address the spatial dependence of excitations in such systems - as relevant for spectroscopic tools routinely used in the experiments.