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Superfluidity and magnetism in flat Bloch bands

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Abstract:

Correlated many-body states of fermions moving in a lattice are at the root of many fascinating phenomena in condensed matter, which are at present still poorly understood. The main example in this sense is high- T_c superconductivity. Understanding the low energy properties of a system of many fermion in a lattice, even in its simplest realization, the Fermi-Hubbard model, is extremely challenging both from the conceptual and the computational point of view.

Therefore it is of paramount importance to find ways to simplify the problem. One possibility is to consider lattices with flat bands, that is Bloch bands with vanishing bandwidth (infinite effective mass). Mielke and Tasaki have proved that a completely polarized ferromagnet is the unique ground state (up to rotations) for a half-filled flat band in a repulsive Hubbard model.

On the other hand we have focused on the attractive case, motivated by the expectation that the diverging density of states of a flat band should boost the superconductive critical temperature. We find that the ground state is well described by the BCS wavefunction, whereas the normal state of a flat band superconductor is not a Fermi liquid and in this sense similar to high- T_c superconductors. We have also related the superfluid weight of a flat band superconductor to the geometric and topological properties of the band structure.

Our results are not limited to the attractive case since in the flat band limit a superconductor can be mapped exactly into a ferromagnet of the Mielke and Tasaki type. Ultracold gases are the most promising platform to verify these predictions

(本セミナーは「物理学第一教室 量子光学セミナー」を領域メンバー向けに TMS セミナーとしてアナウンスしているものです。)

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