Renormalization Group Study Of Ordered Phases In Two-Dimensional Quadratic Band Touching Systems

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Introduction

The appearance of superconductivity (SC) adjacent to charge or spin order is a ubiquitous phenomenon in strongly correlated electron systems. Despite its pervasiveness, the precise mechanism by which SC is realized in these systems remains to be well-understood. We have recently addressed this issue for interacting fermions in quadratic band touching (QBT) systems, in which two parabolic bands meet at a single point in momentum space.

Results and Discussion

In our calculations we employ a renormalization group (RG) approach, which treats all possible phase instabilities on an equal footing and includes the effects of fluctuations in various channels feeding back on one another [1-4]. The results turn out to depend strongly on the number of spin and valley degrees of freedom, with the two-valley QBT (as realized in bilayer graphene) leading to f-wave, chiral d+id, and pair density wave SC [1,2]. For a single QBT, which may be realized on checkerboard or kagome lattices, topological quantum anomalous Hall and quantum spin Hall phases appear adjacent to s-wave or d-wave superconductivity [3,4].

Conclusions

Through our calculations we have shed light on the way in which unconventional superconductivity arises in QBT systems, in particular the way in which attraction is first generated due to fluctuations in non-superconducting channels. At low energies, the combination of this attractive interaction together with the kinematic constraints imposed by the presence of a Fermi surface leads to SC. We expect that our analysis will contribute to a more complete understanding of unconventional superconductivity both in QBT and in other strongly correlated systems.

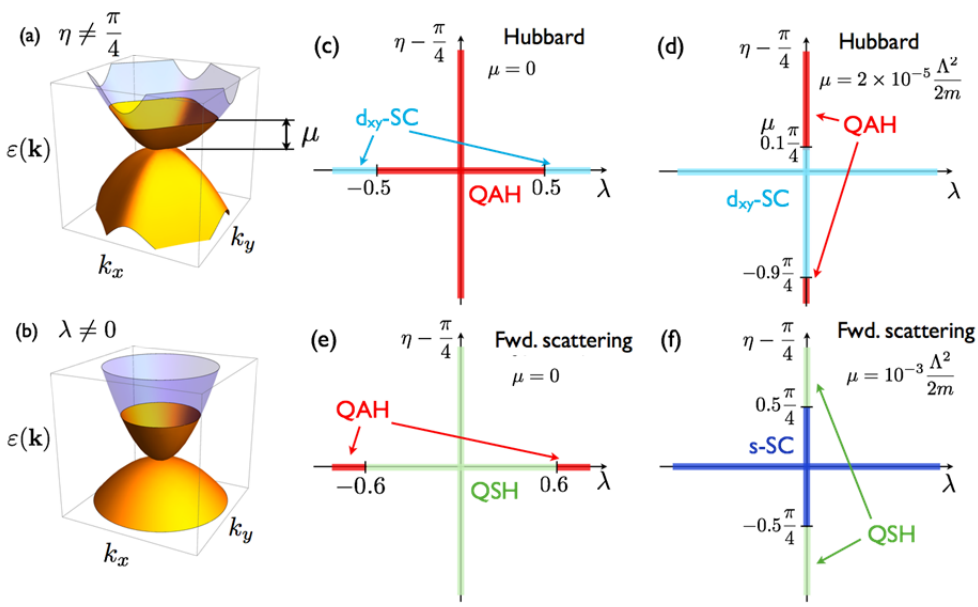

Fig. 1 (a)-(b): Energy bands for a 2D QBT system, with chemical potential and parameters describing rotational and particle-hole anisotropy. (c)-(f): Phase diagrams determined by solving the RG equations for various values of chemical potential and fermion interaction (short-ranged Hubbard or long-ranged forward scattering), with axes for rotational and particle-hole anisotropies. Phases are quantum anomalous Hall, quantum spin Hall, and s- and d-wave SC.

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References

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