第 89 回トポロジカル物質科学セミナー
Topological Materials Science Seminar (89)

Antiferromagnetic semimetals and topological phases combining superconductivity and magnetism

Dr. Mario Cuoco

CNR-SPIN, c/o Università di Salerno, Fisciano (SA), 84084 Italy

Date: February 14 (Thu), 2019

Time: 10:00-12:00

Place: Room273, Faculty of Engineering Bldg. #3, Higashiyama Campus, Nagoya Univ. (名大東山キャンパス工学部3 号館273 号室)

Abstract: The search for new variants of semimetals (SMs) recently highlighted the interplay of Dirac fermions physics and magnetism. Indeed, while most of the currently known SMs are non-magnetic, antiferromagnetic (AFM) SMs can be obtained where both time and inversion are broken while their combination is kept or due to chiral- and time-symmetry combined with non-symmorphic transformations. We discuss specific materials, i.e. transition metal oxide systems, that can exhibit AFM-SM phase due to emergent orbitally directional double-exchange effects. Due to the orbital directionality, the competition between antiferromagnetic (AF) and ferromagnetic (FM) correlations uniquely makes antiferromagnetically coupled FM zigzag stripes and checkerboard clusters the dominant patterns in the phase diagram over a large range of doping. Such zigzag AF states are representative of a class of non-symmorphic antiferromagnets with glide reflection symmetry. Apart from the large variety of fundamental aspects related to Dirac systems, the combination with other type of conventional orders (e.g. magnetism or superconductivity) represents an ideal testbed for achieving new phases of matter and single out materials for future technologies. In this talk, we will discuss mechanisms and potential materials for achieving antiferromagnetic semimetals. Then, we consider the impact of s-wave spin-singlet pairing on AFM-SMs with Dirac points or nodal loops at the Fermi level. The electron pairing is generally shown to convert the semimetal into a tunable nodal superconductor. The changeover from fully gapped to gapless phases is dictated by symmetry properties of the AFM-superconducting state that set the occurrence of a large

Host: Yukio Tanaka [Nagoya Univ. / Core Research Group B01]
(052-789-4447, ytanaka@nuap.nagoya-u.ac.jp)

variety of electronic topological transitions. We provide a general criterion for predicting a series of transitions between nodal and fully gapped superconducting phases. Different types of antiferromagnetic patterns are then employed to explicitly demonstrate the microscopic mechanisms that control the character of the quasiparticle spectrum.
Finally, if time permits, I will review some quantum platforms marked spin-singlet or triplet pairing interfaced with non-trivial magnetic patterns and discuss the nature of the emerging topological superconductors.

References

1. P. Tang, Q. Zhou, G. Xu, and S.-C. Zhang, Nat. Phys. 12, 1100 (2016).
2. W. Brzezicki and M. Cuoco, Phys. Rev. B 95, 155108 (2017).
3. S. M. Young and B. J. Wieder, Phys. Rev. Lett. 118, 186401 (2017).
4. W. Brzezicki, C. Noce, A. Romano, and M. Cuoco, Phys. Rev. Lett. 114, 247002 (2015).
5. W. Brzezicki and M. Cuoco, Phys. Rev. B 97, 064513 (2018).
6. M. T. Mercaldo, M. Cuoco, P. Kotetes, Phys. Rev. B 94, 140503(R) (2016).
7. A. Romano, P. Gentile, C. Noce, I. Vekhter, M. Cuoco, Phys. Rev. Lett. 110, 267002 (2013).
8. M. T. Mercaldo, P. Kotetes, M. Cuoco, Physica B 536, 730 (2018).
9. M. T. Mercaldo, P. Kotetes, M. Cuoco, AIP Advances 8, 101303 (2018).
10. M. T. Mercaldo, P. Kotetes, M. Cuoco, arXiv:1901.00878.

Host: Yukio Tanaka [Nagoya Univ. / Core Research Group B01]
(052-789-4447, ytanaka@nuap.nagoya-u.ac.jp)