第９２回トポロジカル物質科学セミナー
Topological Materials Science Seminar (92)

Intertwined orders and exotic quantum phase transitions in Dirac fermions

Toshihiro Sato

Institut für Theoretische Physik und Astrophysik, Universität Würzburg

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Abstract:
Dirac fermions are among the most active current research areas due to their role in both condensed matter and high-energy physics as well as their experimental realization. In the realm of Dirac fermions in 2+1 dimensions akin to graphene, there are many possible mass terms corresponding to antiferromagnetic (AFM), Kekulé valence bond solid (KVBS), quantum spin Hall (QSH), superconducting (SC) etc states. We aim at discussing intertwined orders in Dirac fermions in terms of the symmetry group of the respective phases and the algebraic properties of the corresponding mass terms. In this talk we will present recent progress in quantum Monte Carlo simulations that models of Dirac fermions in 2+1 dimensions with dynamically generated, anti-commuting mass terms are a golden route to realize exotic quantum phase transitions. First we consider a model with SO(3) AFM and Z_2 KVBS mass terms. Of particular interest is the observation of a continuous transition between AFM and KVBS states. The fermions remain gapped across the transition, and our data support an emergent SO(4) symmetry unifying the two order parameters [1]. In a second step, we place emphasis on a model with SO(3) QSH and U(1) s-wave SC (SSC) mass terms. Most notably, the QSH to SSC transition turns out to be continuous. The corresponding SO(3) QSH order parameter permits both long-wavelength Goldstone modes and topological skyrmion defects with charge 2e. The mechanism for SSC order from QSH state involves the condensation of skyrmion defects of the QSH order parameter [2].

References:

[1] T. Sato, M. Hohenadler, F. F. Assaad, Phys. Rev. Lett. 119, 197203 (2017)
[2] Y. Liu, Z. Wang, T. Sato, M. Hohenadler, C. Wang, W. Guo, F. F. Assaad, arXiv:1811.02583.

Host: Norio Kawakami [Kyoto Univ. / Core Research Group D01]
(075-753-3768, norio@scphys.kyoto-u.ac.jp)