Antiferromagnetic Dirac Semimetals and New fermions beyond Dirac and Weyl models

Dr. Peizhe Tang
Theory Department, Max Planck Institute for the structure and dynamics of matter

Analogues of the elementary particles have been extensively searched for in the condensed-matter systems for both scientific interest and technological applications. For example, the Weyl fermions and Dirac fermions have been predicted and observed in real material candidates. In this talk, I will expand the notion of Dirac fermions into the antiferromagnetic system in which both time reversal symmetry (T) and inversion symmetry (P) are broken but their combination PT is respected. Furthermore, we propose the orthorhombic antiferromagnet CuMnAs as a candidate, analyze the robustness of the Dirac points under symmetry protections, and demonstrate its distinctive bulk dispersions, as well as the corresponding surface states via *ab initio* calculations. Our results provide a possible platform to study the interplay of Dirac fermion physics and magnetism.

In the second part of this talk, we will show that the “new” fermions beyond Dirac and Weyl models, such as such as spin-1 excitations with 3-fold degeneracy and spin-3/2 Rarita-Schwinger-Weyl fermions, could coexist with type-I and type-II Weyl fermions in a family of transition metal silicides, including CoSi, RhSi, RhGe and CoGe, when the spin-orbit coupling (SOC) is considered. Their non-trivial topology results in a series of extensive Fermi arcs connecting projections of these bulk excitations on the side surface, which is confirmed by the surface electronic spectra calculations and ready for ARPES measurements. This work not only identifies desired robust topological semimetal candidates but also provides an ideal platform to explore exotic physical phenomena and future device applications.

[1] Peizhe Tang*, Quan Zhou*, Gang Xu, Shou-Cheng Zhang. Dirac Fermions in an antiferromagnetic semi-metal. *Nature Physics* 12, 1100 (2016).
[2] Peizhe Tang, Quan Zhou, Shou-Cheng Zhang. Multiple types of topological fermions in transition metal silicides. *Physical Review Letters* 119, 206402 (2017).