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Visualizing the Electronic Structure of Topological Dirac Semimetals

YULIN CHEN, Oxford University

Three-dimensional (3D) topological Dirac semimetals (TDSs) represent an unusual state of quantum matter that can be viewed as "3D graphene." In contrast to 2D Dirac fermions in graphene or on the surface of 3D topological insulators, TDSs possess 3D Dirac fermions in the bulk. Moreover, a TDS can potentially be driven into other exotic phases (such as Weyl semimetals, axion insulators or topological superconductors), making it a unique parent compound for the study of these states and the phase transitions between them. By investigating the electronic structure of Na3Bi and Cd3As2 with angle-resolved photoemission spectroscopy including kz information, we discovered bulk (3D) Dirac fermions with linear dispersions along all three momentum directions in both materials. Furthermore, we can demonstrate the robustness of these 3D Dirac fermions against in situ surface doping, showing the protection of the bulk crystal symmetry. These findings establish both materials as model systems of 3D TDSs, which can also serve as ideal platforms for exploring exotic physical phenomena and novel applications.