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Observation of Weyl fermions, Fermi arcs and chirality in Weyl semimetals[1]

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A Weyl semimetal is a novel topological phase that hosts Weyl fermions as emergent quasiparticles and admits a topological classification that protects Fermi arc surface states. We report our latest theoretical and experimental progress on topological semimetals. First, we present a methodology for searching for topological semimetals by sifting through the materials parameter space, using which we show the theoretical identification of a large number of candidate materials with distinct topological properties. Second, we show photoemission spectroscopy measurements. By measuring the bulk and surface band structures, we directly observe the Weyl fermions and the Fermi arcs in both type-I and type-II Weyl semimetals. Third, we report on the mid-infrared optoelectronic response of the Weyl semimetal TaAs. We show that the coupling between Weyl fermions and chiral photons leads to a giant photocurrent, which allows us to detect the chirality of the Weyl fermions in TaAs. Our theory and photoemission experiments discover the first Weyl semimetal in real materials, and our photocurrent results represent an initial attempt to control and manipulate the Weyl fermions and the associated quantum anomalies by electrical and optical means.

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