Experimental Evidence of Six-Fold Degenerate Fermions in $PdSb_2$

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Condensed matter systems can exhibit quasiparticle excitations which mimic the wavefunctions of exotic fermions predicted in high energy physics. For example, Dirac and Weyl fermions exist as low energy electronic excitations of several semimetals near the Dirac points and Weyl points. Most interestingly, condensed matter systems can also realize novel fermions which have no counterpart in high energy physics because the former do not need to follow certain symmetries which are mandatory for the latter. Bradlyn *et al.* discovered that one can find threefold, sixfold, or eightfold degenerate symmetry protected points in many compounds [1]. While the threefold points can be realized in both nonsymmorphic [1,2] and symmorphic crystal structures [2], nonsymmorphic operations are essential for stabilizing sixfold and eightfold degenerate points. **The present study shows that the nonsymmorphic compound $PdSb_2$ hosts six-component fermions or sextuplets.** The sextuple points have been recently observed experimentally in the chiral compound CoSi, RhSi, and AlPt in the space group $P2_13$ (198) [3–5]. However, the latter study was mainly focused on establishing the existence of surface Fermi arcs, which are a consequence of the large Chern number associated with the sixfold crossings in this space group. By contrast, here we show for the first time the existence of sextuple points that have a vanishing Chern number and are therefore expected to show no surface Fermi arcs [6].

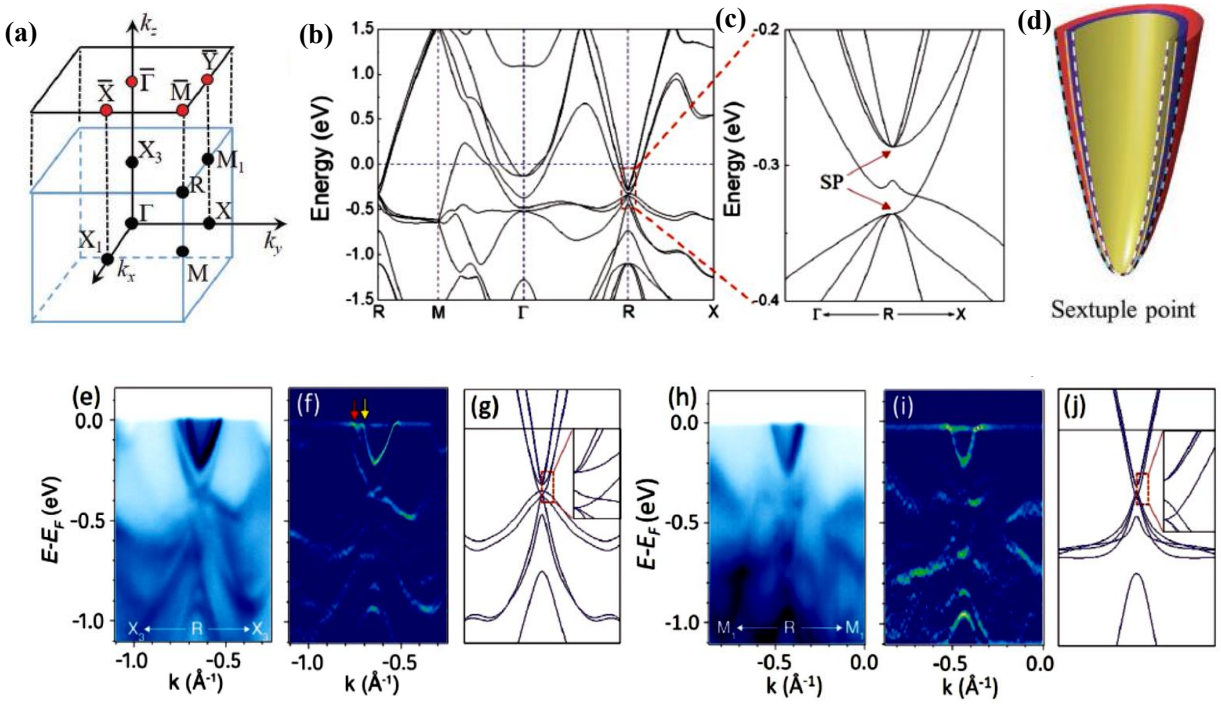

FIGURE 1. a) 3D bulk Brillouin zone (BZ) and (001) surface BZ with the high symmetry points highlighted. b) Calculated band structure along *R*–*M*–Γ–*R*–*X*. Two sextuple points (SPs) are observed at the *R* point at −0.286 & −0.334 eV below the Fermi level, indicated by red arrows in the magnified image on the right (c). Schematic representation of sextuple points (d). e) Measured band dispersion along the X_3–R–X_3 direction, at the photon energy 65 eV. f) The corresponding curvature intensity plot. g) Calculated band structure along X_3–R–X_3. Inset shows the magnified view near the sextuple point. h–j) ARPES intensity plot, the corresponding curvature intensity plot, and the calculated band structure along M_1–R–M_1.

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