Landau Levels and Zeeman Splitting of Three-dimensional Massless Dirac Fermions in ZrTe5

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Recently Prof. N.L.Wang's group in Peking University applied moderate magnetic field on ZrTe5 and observed optical reflectance peaks at a sequence of frequencies. The peak frequencies and their dependence on magnetic field closely follow the behavior of Landau levels formed by gapless Dirac fermions. At high magnetic field the refletance peaks further split, which can be interpreted as Zeeman splitting of Landau levels. We built a low energy effective model for ZrTe5 based on previous DFT results and studied the effects of Zeeman field and Landau level formation. Our analysis indicates that the Zeeman field under current experimental setup transforms the gapless/narrow-gap Dirac fermions in ZrTe5 into a "line node" semimetal, and the orbital effect of field further produces Zeeman-split Landau levels. We suggest that Zeeman field along another crystal axis can transform this material into Weyl semimetals. This material has a very low magnetic field threshold for quantum limit and will be a good platform for future studies of gapless/narrow-gap 3D Dirac fermions in solid state systems.

References:

[1] Phys. Rev. Lett. 115, 176404 (2015)