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Three Dimensional Dirac Semimetals[1]

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Dirac points on the Fermi surface of two dimensional graphene are responsible for its unique electronic behavior. One can ask whether any three dimensional materials support similar pseudorelativistic physics in their bulk electronic spectra. This possibility has been investigated theoretically and is now supported by two successful experimental demonstrations reported during the last year. In this talk, I will summarize the various ways in which Dirac semimetals can be realized in three dimensions with primary focus on a specific theory developed on the basis of representations of crystal spacegroups. A three dimensional Dirac (Weyl) semimetal can appear in the presence (absence) of inversion symmetry by tuning parameters to the phase boundary separating a bulk insulating and a topological insulating phase. More generally, we find that specific rules governing crystal symmetry representations of electrons with spin lead to robust Dirac points at high symmetry points in the Brillouin zone. Combining these rules with microscopic considerations identifies six candidate Dirac semimetals. Another method towards engineering Dirac semimetals involves combining crystal symmetry and band inversion. Several candidate materials have been proposed utilizing this mechanism and one of the candidates has been successfully demonstrated as a Dirac semimetal in two independent experiments.

[1]Work carried out in collaboration with: Julia A. Steinberg, Steve M. Young, J.C.Y. Teo, C.L. Kane, E.J. Mele and Andrew M. Rappe