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Weyl semimetal phase in solid-solution zero-gap semiconductors

DAICHI KUREBAYASHI, KENTARO NOMURA, Institute for Materials Research, Tohoku University — Weyl semimetals are recently found novel magnetic materials with the pseudo-relativistic linear dispersions. Near the band-touching points, the excitations are described by the Dirac-Weyl Hamiltonian. Quasiparticles, Weyl fermions, are assigned by a chirality, and the bulk gap opens only if two Weyl fermions with opposite chirality meet each other. This topological behavior originates in the nonzero Berry curvature enclosing a Weyl point. In $TlBi(Se_{1-x}S_x)_2$, it was recently found that the bulk gap closes as substituting sulfur by selenium. This vanishing of bulk gap is considered as the topological phase transition, and it is expected that the Weyl semimetal phase can be realized in this regime by breaking time-reversal symmetry. We determine the condition for the Weyl semimetal caused by a magnetic transition in zero-gap semiconductors doped with magnetic impurities. As a model, we use the Wilson Hamiltonian and the s-d exchange Hamiltonian within the mean-field approximation. We calculate the magnetization by solving the Hamiltonian self-consistently and obtain the topological phase diagram. Consequently, we find the Weyl semimetal phase with the finite anomalous Hall conductivity can be realized below the Curie temperature depending on the impurity concentration.

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