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Ferromagnetic interactions between transition-metal impurities in topological and 3D Dirac semimetals TOMASZ DIETL, Inst Phys, Polish Acad of Sci; Inst Theor Phys, Univ Warsaw; WPI-AIMR Tohoku Univ — The magnitude of ferromagnetic coupling driven by inter-band (Bloembergen-Rowland - BR) and intra-band (Ruderman-Kittel-Kasuya-Yoshida - RKKY) spin polarization is evaluated within kp theory for topological semimetals $Hg_{1-x}Mn_xTe$ and $Hg_{1-x}Mn_xSe$ as well as for 3D Dirac semimetal $(Cd_{1-x}Mn_x)_3As_2$. In these systems Mn^{2+} ions do not introduce any carriers. Since, however, both conduction and valence bands are built from anion p-type wave functions, hybridization of Mn d levels with neighboring anion p states leads to spin-dependent $p-d$ coupling of both electrons and holes to localized Mn spins, resulting in sizable inter-band spin polarization and, thus in large BR interactions. We demonstrate that this ferromagnetic coupling, together with antiferromagnetic superexchange, elucidate a specific dependence of spin-glass freezing temperature on x, determined experimentally for these systems. Furthermore, by employing a multi-orbital tight-binding method, we find that superexchange becomes ferromagnetic when Mn is replaced by Cr or V. Since Cr should act as an isoelectronic impurity in HgTe, this opens a road for realization of ferromagnetic topological insulators based on (Hg,Cr)Te.

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