RKKY coupling in diluted magnetic semiconductors

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RKKY coupling, *i.e.*, the exchange interaction between localized core spins mediated by metallic electron gas is known for 50 years as the basic interaction in metallic ferromagnets. It rules the interlayer coupling in magnetic layered structure. The oscillatory character of RKKY interaction causes the spin glass behavior in diluted magnetic metal. As it has been shown for last few years RKKY interaction is also the dominant spin interaction in diluted ferromagnetic semiconductors. However, in the case of semiconductors, strictly speaking in semimetallic phase of semiconductors, the Fermi energy, E_F, is smaller as compared to classical metals and comparable to the exchange spin splitting of conduction band, Δ. The small Fermi energy causes a saturation spin polarization of carrier spins (that problem has been already analyzed by Nagaev) and some other new effects.
In our presentation we discuss another consequence of the spin splitting on the RKKY coupling. We analyze the analytic expression for the distance dependence of exchange coupling showing that:

- In the presence of spin splitting the RKKY exchange is not anymore of Heisenberg type but leads to the magnetization induced anisotropy. For the material parameter of (Ga,Mn)As it is the dominant anisotropy energy.
- Two contributions to the RKKY coupling, characterized by different distance dependencies, occur: (i) the higher, classical one, corresponding to a mean Fermi *k*-vector and (ii) the lower one matching to the difference of the Fermi *k*-vectors for up and down spin subbands.

The discussion of the dependence of exchange coupling on the ratio Δ/E_F allows to follow the evolution of spin interaction from the classical RKKY interaction in metals, *via* the modified RKKY interaction in semimetallic diluted magnetic ferromagnets, to the Zener magnetism in diluted magnetic semiconductors.

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