Control of transport in semiconducting MnTe by magnetic order

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Transport properties of semiconductors depend sensitively on several factors and here, Fermi level position is the most prominent one. In magnetically ordered systems, direction of the magnetic moments (and also the degree of their disorder) is another such factor. In the present work, we investigate both theoretically and experimentally their interplay in a model system of p-type antiferromagnetic MnTe.

We first discuss the location of Fermi surface within Brillouin zone; it has recently been argued that valence band maxima can occur not only close to the A-point but, for some values of lattice parameters, also in the vicinity of Γ even if under circumstances (bulk, room temperature) the former should prevail [1]. Next, we use the effective 6×6 model $H_{kp} + H_{so}$ from this article to locate the Fermi surface (for experimentally determined carrier concentrations) and find that it is slightly displaced from A. Earlier measurements [2] detected crystalline anisotropic magnetoresistance [3] and we use the effective model to calculate this DC transport quantity; conceptual differences in this approach to the case of dilute magnetic semiconductors such as (Ga,Mn)As will be highlighted. We also show how this model can be used to calculate spin currents (which occur even in the absence of the spin-orbit interaction [4]) and finally, we turn our attention to transport measurements at non-zero frequencies.

To this end, motivated by the recent measurements of the anomalous Hall effect in MnTe [5], we measure polar Kerr spectra in optical range and discuss their microscopic origin. We find similarities with ab initio calculations [6] and show, using the effective model, how they depend on Fermi level. Non-zero signal (σ_{xy} at zero magnetic field) requires unequal population of time-reversal-linked antiferromagnetic domains (e.g. ↑↓ and ↓↑) and we outline a mechanism that could drive the system into this state.

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