Interplay between altermagnetism and nonsymmorphic symmetries generating large anomalous Hall conductivity by semi-Dirac points induced anticrossings

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Altermagnetism is a new variant in collinear magnetism which shares properties of both ferromagnetic and antiferromagnetic compounds where the magnetization is compensated due to opposite spin configurations in real space and a broken time reversal symmetry designated by the spin-splitting of the band structure in the reciprocal space. In this case, the Kramer's degeneracy is lifted and spin-up/spin-down sublattices are mapped by roto-translational symmetries [1].

In this work, we have studied the compound CrAs which is naturally an antiferromagnet (AFM) but shows altermagnetic behaviour only in its C-type AFM and belongs to the Pnma crystal structure which is known to exhibit non-symmorphic symmetries; which are a composition of fractional lattice translations with point-group operations, like mirror reflection (glide plane) or rotation (screw axis). The nonsymmorphic symmetries produce additional degeneracies at the border of the Brillouin zone. The interplay between the nonsymmorphic symmetries and altermagnetism produced a network of band crossings and anti-crossings near the Fermi level which was studied as a function of the direction of the Néel vector with and without spin-orbit coupling (SOC)[2].

Upon the addition of SOC, we observe a selective removal of the spin degeneracy depending on the Néel vector direction and consequently on the magnetic space group. When the Néel vector is along x, we have additional SOC splittings for all the crossing and anticrossing points except that for one intrachannel crossing point which would be a nodal line in the altermagnetic phase. The SOC splits the remaining band crossings and band anticrossings, producing a large anomalous Hall effect in all directions excluding the Néel-vector direction. It has been shown that the Dzyaloloshinskii-Moriya interaction (DMI) allows the rise of weak ferromagnetism for a suitable Néel vector orientation which can be enhanced by breaking the inversion symmetry[3,4]

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