Spin-momtum locking in ferromagnets

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The relativistic spin-momentum locking has been proven in time-reversal-breaking classes of materials with zero net magnetization in the non-relativistic limit, such as altermagnets and other non-collinear magnets. Using density functional theory calculations on prototypical ferromagnets such as orthorhombic $SrRuO_3$, hexagonal CrTe and CrAs with the NiAs crystal structure, half-Heusler MnPtSb, and fcc Ni, we aim to show the presence of relativistic spin-momentum locking in different classes of ferromagnets and to unveil their properties. In $SrRuO_3$, the antisymmetric exchange interaction produces a spin canting orthogonal to the easy axis, but even when the canted magnetic moment in real space is forbidden, relativistic spin-momentum locking shows sizable contributions in k-space. Subdominant components of centrosymmetric ferromagnetic materials with magnetic sites connected by rotational symmetry host a single spin-momentum locking similar to altermagnets, while noncentrosymmetric MnPtSb hosts interplay with the relativistic p-wave, and fcc Ni shows a more complex behavior with a combination of two spin-momentum locking patterns. Because ferromagnets typically have larger bandwidths than altermagnets, they provide a promising platform for observing even-wave relativistic spin-momentum locking and associated emergent phenomena. From an application standpoint, relativistic spin-momentum locking governs symmetry-allowed spin Hall currents, spin photocurrents, and other momentum-dependent spin responses in k-space.

References:

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