[QMS2020 invited talk]

Topological spintronics in antiferromagnets and the crystal Hall effect

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The effective manipulation of antiferromagnets (AF), through the recently proposed and discovered Néel spin-orbit torque, has turned AFM into active elements of spintronic devices. This, coupled with the inherent topological properties of their band-structure, makes topological antiferromagnetic spintronics a fruitful area of exploration. A key remaining challenging aspect is the observation of the Néel order parameter. Here we show that the anomalous Hall effect can play a key role, which over a century, continue to play a central role in condensed matter research for their intriguing quantum-mechanical, relativistic, and topological nature. Here we introduce a microscopic mechanism whose key component is an asymmetric spin-orbit coupling originating from lowered symmetry positions of atoms in the crystal. Based on first-principles calculations, we demonstrate a pristine form of this crystal Hall effect in a room-temperature rutile antiferromagnet RuO2 whose Hall conductivity reaches 1000 S/cm. While a collinear antiferromagnetic order of magnetic moments alone would generate zero Hall response, the effect arises when combining it with the spin-orbit coupling due to non-magnetic atoms occupying non-centrosymmetric crystal positions. The crystal Hall effect can also explain recent measurements in a chiral antiferromagnet CoNb3S6, and we predict it in a broad family of collinear antiferromagnets [1].

[1] Libor Šmejkal, Rafael González-Hernández, Tomáš Jungwirth, Jairo Sinova, arXiv:1901.00445