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Electrical switching of an antiferromagnet

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Louis Néel pointed out in his Nobel lecture that while abundant and interesting from theoretical viewpoint, antiferromagnets did not seem to have any applications. Indeed, the alternating directions of magnetic moments on individual atoms and the resulting zero net magnetization make antiferromagnets hard to control by tools common in ferromagnets. Strong coupling would be achieved if the externally generated field had a sign alternating on the scale of a lattice constant at which moments alternate in antiferromagnets. However, generating such a field has been regarded unfeasible, hindering the research and applications of these abundant magnetic materials. We will discuss a recent prediction that relativistic quantum mechanics may offer a staggered current induced field whose sign alternates within the magnetic unit cell. The staggered spin-orbit field can facilitate a reversible switching of an antiferromagnet with comparable efficiency to the switching of ferromagnets by conventional uniform magnetic fields. We will then discuss suitable antiferromagnetic materials and a demonstration of the complete writing/storage/readout functionality in PC compatible demonstrator device. The absence of dipolar fields in the zero net moment antiferromagnets allows for a multiple-stability of the memory states that are invisible to magnetic probes and robust against external magnetic field perturbations. Moreover, antiferromagnets have ultra-fast internal spin dynamics, opening the prospect of picosecond timescales for switching, both in the coherent single domain regime and by ultra-fast domain wall motion.
References:
[1] P. Wadley et al. Science 351, 587 (2016); C. Marrows (Editorial), Science 351, 558 (2016).
[2] T. Jungwirth et al., Nature Nanotech. 11, 231 (2016); Editorial, Nature Nanotech. 11, 231 (2016).

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