Reversible ionic control of antiferromagnetic anisotropy

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Antiferromagnets (AFMs) are a ubiquitous class of magnetic materials, holding the promise of low-dissipation spintronic computing devices that can display ultra-fast switching, density scaling and robustness against stray fields\(^1\). However, magnetic sublattice compensation makes it difficult to detect and control AFM textures in a reversible and scalable manner via standard techniques\(^2\).

We overcame this limitation by developing a novel ionic approach to reversibly tailor AFM anisotropy\(^3\). We focussed on the earth-abundunt AFM \(\alpha\text-\text{Fe}_2\text{O}_3\), which exhibits a spin-reorientation (Morin) transition between in-plane and out-of-plane configurations. Developing reversible control of AFM anisotropy in \(\alpha\text-\text{Fe}_2\text{O}_3\) is important for prospects in (i) topological spintronics\(^4,5\) and (ii) magnonics\(^6,7\). Regarding the former, I will discuss our recent results where the Morin transition was exploited to stabilize a wide family of exotic AFM topological textures - half-skyrmions and bimerons - at room temperature. These topological textures have core sizes (of \(\approx 100\) nm) and can be scaled further with anisotropy tuning\(^4\).

In this context, I will discuss our findings on ionic control of antiferromagnetism in epitaxial \(\alpha\text-\text{Fe}_2\text{O}_3\) films\(^3\). The catalytic-spillover process employs Pt nano-structures to hydrogenate the AFM films, thereby, driving pronounced changes in the anisotropy, Néel vector orientation and canted magnetism via local charge-doping. As H ions are very small and light, they can be added/removed from the host lattice, without significantly disturbing the overall structure. This allows our approach to be stable yet reversible\(^3\). Tailoring our work for future applications, we demonstrated reversible control of the room-temperature AFM-state by doping/expelling H ions in Rh-substituted \(\alpha\text-\text{Fe}_2\text{O}_3\). I will conclude by presenting the wider implications of our work, such as how AFM-state control could eventually be realized with E-fields\(^8\) and translated to a wider variety of AFMs (e.g. orthoferrites, orthochromites)\(^9\), enabling the construction of low-energy antiferromagnetic applications.

References:


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