Discovery and control of room-temperature antiferromagnetic topological textures

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Ferromagnetic skyrmions and their anti-particles have shown great promise as topologically-protected information carriers for racetrack or neuromorphic applications[1]. However, presence of dipolar fields, restricting the formation of ultra-small textures, and the deleterious skyrmion Hall effect, have so far inhibited their practical implementation[2]. Alternatively, antiferromagnetic (AFM) analogues, made from topological whirling of compensated sublattices, are predicted to exhibit relativistic dynamics, deflection-free motion and size scaling[2,3]. While the latest observations of skyrmions in synthetic AFM stacks have exhibited some desirable properties[4], equivalent demonstrations in natural AFM systems are yet to emerge. Moreover, sublattice compensation also makes it very difficult to directly detect and control AFM textures via standard techniques.

Here, I will firstly discuss a recently-developed approach to perform vector-mapping of the Néel order-parameter in AFM textures using angle-dependent dichroic photoemission microscopy[5,6]. Then, I will present a general field-free approach, employing the Kibble–Zurek transition[6], that we used to realize a wide family of topological AFM textures, including exotic Bloch and Néel merons or antimerons (half-skyrmions) and bimerons (topologically equivalent to skyrmions). In the earth-abundant oxide – hematite (α-Fe_2O_3) – capped with a Pt over-layer, these textures can be nucleated and stabilized at room temperature. They have characteristic sizes of the order 100 nm and are experimentally tunable via control of the exchange, anisotropy and interfacial interactions[6]. I will then briefly present our new ionic approach to control AFM anisotropy in a non-volatile and reversible manner[7], which may eventually be driven via electric-fields to engineer the above topological textures. I will conclude by discussing how our results may be translatable to a wider family of AFM materials[7]. Given that currents in the Pt over-layer are known to provide spin-orbit torques to the AFM under-layers[8], it may soon become possible to electrically drive some members of the topological family, thereby paving a new pathway towards the construction of low-energy antiferromagnetic applications[1,2,3].

References:

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Work at NUS was supported by National Research Foundation, Singapore (NRF2015 NRF-CRP001-015)