Real-space Imaging of Non-collinear Antiferromagnetic Order with a Single Spin Magnetometer

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While ferromagnets are at the heart of daily life applications, the large magnetization and energy costs for switching bring into question their suitability for reliable low-power spintronic devices. Non-collinear antiferromagnetic systems do not suffer from this problem and often possess remarkable extra functionalities: non-collinear spin order1 may break space-inversion symmetry2,3 and thus allow electric-field control of magnetism4,5, or produce emergent spin-orbit effects6,7 which enable efficient spin-charge interconversion8. To harness these unique traits for next-generation spintronics, the equivalent nanoscale control and imaging capabilities, now routine for ferromagnets, must be developed for antiferromagnetic systems. Here, using a non-invasive scanning magnetometer based on a single nitrogen-vacancy (NV) defect in diamond911, we demonstrate the first real-space visualization of non-collinear antiferromagnetic order in a magnetic thin film, at room temperature. We image the spin cycloid of a multiferroic BiFeO3 thin film and extract a period of ~70 nm, consistent with values determined by macroscopic diffraction12,13. In addition, we take advantage of the magnetoelectric coupling present in BiFeO3 to manipulate the cycloid propagation direction with an electric field. Besides highlighting the unique potential of NV magnetometry for imaging complex antiferromagnetic order at the nanoscale, these results demonstrate how BiFeO3 can be used as a versatile platform for the design of reconfigurable nanoscale spin textures.

5 J.T. Heron et al., Nature 516, 370-373 (2014)