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Complex Magnetic Structure in strained nanoscale bismuth ferrite thin films

Multiferroic materials demonstrate excellent potential for next-generation multifunctional devices, as they exhibit coexisting ferroelectric and magnetic orders. Bismuth ferrite (BiFeO3) is a rare exemption where both order parameters coexist far beyond room temperature, making it the ideal candidate for technological applications. In particular, multiferroic thin films are the most promising pathway for spintronics applications. Therefore we have investigated BiFeO3 thin films by neutron diffraction. At present, the underlying physics of the magnetoelectric coupling is not fully understood and competing theories exist with partly conflicting predictions. For example, the existence of spin cycloid is a mandatory requirement to establish a direct magnetoelectric coupling. Thus far internal strain in epitaxially grown films has limited the stability of the spin cycloid for BiFeO3 films with less than 300 nm thickness, causing the spin cycloid to collapses to a collinear G-type antiferromagnetic structure. Our neutron diffraction experiments have demonstrated that we were able to realize a spin cycloid in films of just 100 nm thickness through improved electrostatic and epitaxial constraints. This underlines the importance of the correct mechanical and electrical boundary conditions required to achieve emergent spin properties in mutiferroic thin film systems. The discovery of a large scale uniform cycloid in thin film BiFeO3 opens new avenues for fundamental research and technical applications that exploit the spin cycloid in spintronic or magnonic devices.

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