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Controlling Magnetism in Multiferroic $BiFeO_3$

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$BiFeO_3$ (BFO) is a room-temperature multiferroic combining large electric polarization with an antiferromagnetic structure with a superimposed long-wavelength (62 nm) cycloidal modulation. Large single crystals of BFO have become available recently, opening up new opportunities for experiments. In this talk, we discuss various ways of controlling magnetism in BFO single crystals using coupling between the ferroelectric and magnetic order parameters. Electric field can rotate the electric polarization and Fe spins simultaneously, and a chiral magnetic monodomain state can be obtained. Populations of the 3 equivalent cycloidal magnetic domains can be controlled by an electric field through piezoelectric coupling. Alternatively, they can be controlled via the inverse effect by applying uniaxial pressure. Very small (~50 bar) pressures producing tiny elastic strain ($\sim 10^{-5}$) are needed to move the magnetic domain walls. Using polarized small-angle neutron scattering, we show for the first time that the spins in the cycloid are tilted, producing local weak ferromagnetism (0.06 μ_B rms value), confirming a long-standing theoretical prediction. This shows that intrinsic macroscopic ferromagnetism could be expected in strained BFO, in which the cycloid is suppressed. Combined with the ability to control the magnetic domains by an electric field or tiny deformation, this observation accentuates the potential of BFO for room-temperarture applications involving magnetoelectric effects.