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Understanding Magnetism in Multiferroics

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Multiferroics are interesting materials not only because of their exciting order parameters, but for the potential for parameter coupling. In order to understand the magnetoelectric coupling, the individual order parameters must first be understood. BiFeO3 (BFO), a room temperature ferroelectric and an antiferromagnet, is an excellent model system for understanding the coupling between ferroelectricity and magnetism. A combination of in-plane and out-of-plane piezoresponse force microscopy (PFM) allows 3D mapping of the ferroelectric polarization directions in micron-sized regions of the films. The magnetic order of BFO was obtained by using x-ray linear dichroism images using a photoelectron emission microscope (PEEM). When compared with our dichroism models, angle and temperature dependent absorption measurements allow decoupling and direction determination of the two order parameters, ferroelectric and magnetic, contributing to the photoemission signal. These studies reveal a strain-driven reduction in magnetic symmetry in thin films, leading to the formation of a preferred magnetic axis as opposed to the observed easy plane for bulk films. This reduction along with the previous proof of FE-AFM coupling allows electrical control of its magnetic axis. This electrical BFO control has a strong effect on ferromagnets even at room temperature.