Routes to synthetic magnetoelectric coupling across interfaces

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Novel electric and magnetic properties can be achieved in materials engineered at nanometer dimensions. Examples include conducting or magnetic interfaces between materials that are neither conducting nor magnetic. New functionality stems from the atomic, charge, spin or orbital structure of the interface. With an understanding of interface structure, electric and magnetic degrees of freedom may be controlled, ideally at room temperature, to achieve synthetic magnetoelectric coupling in a nanocomposite or possibly to control spin textures in topological materials.

In this talk I describe applications of polarized neutron reflectometry (PNR) to probe magnetic interfaces in heterostructures and nanocomposites. In one application, I discuss the origin of a novel form of magnetism in nominally antiferromagnetic $BiFeO_3$ (BFO) when sandwiched between $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) layers. Our results exclude charge transfer, intermixing, strain and octahedral rotations/tilts as dominating mechanisms for large uncompensated magnetization we see in thin BFO layers. We show that the BFO is simultaneously ferrimagnetic and ferroelectric to 200 K.

A second application illustrates the use of ionic liquids (IL) to reversibly switch the ferroelectric (FE) polarization of large area $PbZr_{0.2}Ti_{0.8}O_3$ (PZT) films. Control of the polarization enabled us to show that hole accumulation and depletion induced by the FE polarization leads to a reduction or an enhancement, respectively, of the interface magnetism. IL-assisted FE gating may enable new applications of magnetoelectric coupled multiferroics—ones that operate at room temperature.

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