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Reversal of Magnetic Interactions by Electric field

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Direct magneto-electric coupling describes the interaction between magnetic and electric polarization through an intrinsic microscopic phenomenon in a single phase material. Systems which exhibit such coupling are potential candidates for use in a multistate logic memory storage device whereupon magnetic control with electric fields or ferroelectric control with magnetic fields could be used to alter memory bits. I will present x-ray resonant magnetic scattering results providing direct evidence of a magneto-electric cross field effect mediated through strong spin-lattice coupling in a single phase rare earth titinate film. Compressively strained $EuTiO_3$ is, as in bulk, an antiferromagnetic-paraelectric material, however through strain the balance of the magnetic interactions, both antiferromagnetic and ferromagnetic, shifts whereby the two approach energetic degeneracy. By applying an electric field *in-situ* one can tip the delicate equilibrium and suppress the long range antiferromagnetic order. This is accompanied by the emergence of short range ferromagnetic order. In addition we have qualitatively replicated the microscopic preferential shift from antiferromagnetic to ferromagnetic order with electric field using first principles density functional calculations.