Charge driven magnetoelectric coupling in a ferromagnetic / ferroelectric bilayer

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The present drive towards materials functionalization has rekindled interest in the so-called multiferroic materials, which are characterised by a coupling between magnetic and electric properties. While the magnetoelectric coupling exhibited by the classical ferroic compounds is very weak, and improvements in the material properties of these materials has remained elusive, a new class of composite materials, combining dissimilar magnetic and electric materials, are expected to deliver the required functionality through artificially enhanced magnetoelectric couplings. Here, we present direct, charge-mediated magnetoelectric coupling in a bilayer of ferromagnetic $La_{0.8}Sr_{0.2}MnO_3$ and ferroelectric $Pb(Zr,Ti)O_3$. Using magneto-optic Kerr effect magnetometry, we demonstrate the control of magnetic order through the ferroelectric field effect, by direct measurement of the magnetic order parameter. Key results include a direct measurement of the magnetoelectric coupling parameter by measuring the magnetic response of the PZT/LSMO system as a function of applied electric field, a 20K shift of the magnetic Curie temperature of the LSMO layer upon switching the electric polarization of the PZT layer and an electric field-controlled on/off switching of magnetism in the LSMO layer. These experiments show that artificial multiferroics made of multilayers of ferromagnetic and ferroelectric materials open new possibilities for the development of magnetoelectric devices with large coupling between electric and magnetic degrees of freedom.