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Origin of Interface Magnetism in $BiMnO_3/SrTiO_3$ and $LaAlO_3/SrTiO_3$ Heterostructures

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Possible ferromagnetism induced in otherwise non-magnetic materials has been motivating intense research on diluted semiconductors and complex oxide heterostructures. Here we show that a confined magnetism is realized at the interface between $SrTiO_3$ and two insulating polar oxides, i.e. $BiMnO_3$ and $LaAlO_3$. By using polarization dependent x-ray absorption spectroscopy, we find in both cases that the magnetic order is stabilized by a negative exchange interaction between the electrons transferred at the interface and localized magnetic moments. These local magnetic moments are associated to Ti^{3+} ions at the interface itself, for $LaAlO_3/SrTiO_3$, and to Mn^{3+} ions in the overlayer, for $BiMnO_3/SrTiO_3$. In $LaAlO_3/SrTiO_3$ magnetism is quenched by annealing in oxygen, suggesting a decisive role of oxygen vacancies. These results provide a unified picture of magnetism in titanate interfaces and help reconciling two conflicting phenomena such as ferromagnetism and superconductivity, both observed in $LaAlO_3/SrTiO_3$.

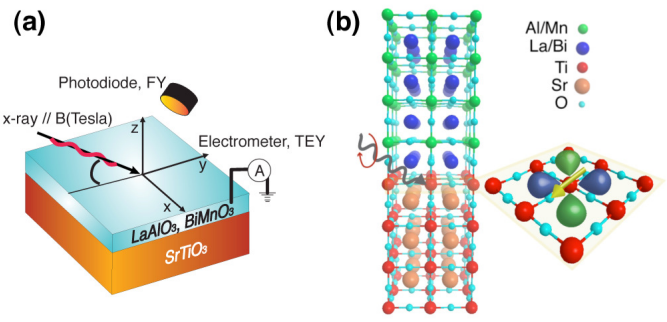

Fig.
Linear and circular dichroism in the XAS of SrTiO3 interfaces. (a) Schematics of the experimental setup: by absorption of a photon (zigzag red arrow) of appropriate energy and known polarization, a Ti or Mn 2p electron is promoted to the 3d states. The external magnetic field B is always parallel to the beam direction and the sample can be oriented at normal (0) or 70 incidence. (b) The crystal structure of an ideal 4 unit cell polar insulating oxide film ($LaAlO_3$ or $BiMnO_3$) deposited on TiO_2 terminated SrTiO3 single crystal, and a pictorial view of the outcomes of Ti $L_{2,3}$ XMCD and XLD, which provide insight on the symmetry and occupation of lowest-lying 3d states (Ti-3dxy orbitals in the picture), and on the consequent magnetic moments (yellow arrow).