Ubiquitous long-range antiferromagnetic coupling across the interface between superconducting and ferromagnetic oxides

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The latest advancements in the atomic control of oxide heterostructures represents a unique opportunity for the uncovering of unsolved topics in condensed matter physics. Using a combination of polarization dependent x-ray absorption spectroscopy and atomically resolved electron spectro-microscopy, we investigated the interplay between superconductivity and magnetism in manganite/cuprate superconductor $La_{0.66}Sr_{0.33}MnO_3$ / $La_{1.85}Sr_{0.15}CuO_4$ superlattices. We found that the charge transfer of spin-polarized electrons from the $La_{0.66}Sr_{0.33}MnO_3$ ferromagnet to the CuO_2 layers of $La_{1.85}Sr_{0.15}CuO_4$ induces an unusual weak ferromagnetic order in the superconductor. This unusual magnetic order is associated to the canting of the Cu^{2+} magnetic moments and propagates inside the superconductor via the Dzyaloshinskii-Moriya interaction over distances from the interface much larger than the superconducting coherence length. This effect modifies substantially the magnetic correlations within and among the CuO_2 planes, ultimately reducing the superconducting critical temperature *of* the cuprate layer in the superlattice.

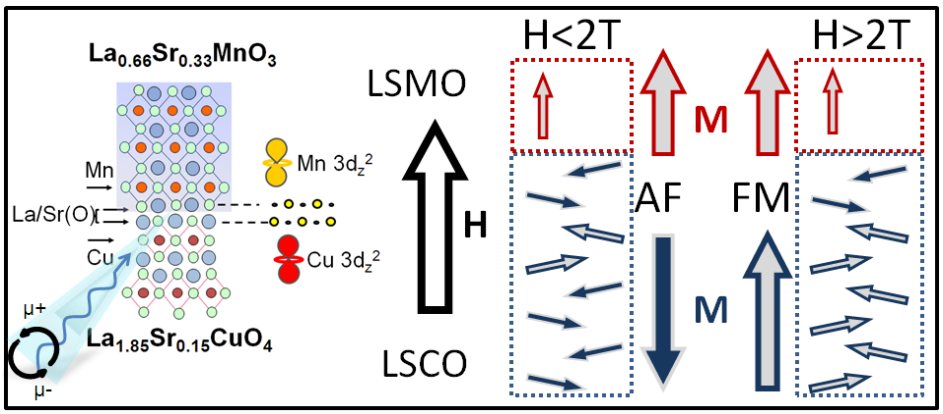

Fig.
On the left of the panel circular x-ray beam in the two directions from synchrotron source is absorbed or diffracted from the interfacial atoms belonging to ferromagnetic $La_{0.66}Sr_{0.33}MnO_3$ (LSMO) and superconductor $La_{1.85}Sr_{0.15}CuO_4$ (LSCO) crystals. On the right of the panel, we show at the LSCO/LSMO interface a strong AF coupling between Mn (red/grey) and Cu (blue/grey) moments is established. The Dzyaloshinskii-Moriya interaction for H<2T propagates the antiparallel orientation of Cu with respect to Mn far from the interface, whereas for H>2 T the external field establishes a parallel direction as in bulk LSCO.