Highlights

RESEARCH AREA 3 - **Quantum Science and technologies** - 2022

"Orbital selective switching of ferromagnetism in an oxide quasi two-dimensional electron gas"

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Multi-orbital physics in quasi-two-dimensional electron gases (q2DEGs) triggers intriguing phenomena not observed in bulk materials, such as unconventional superconductivity and magnetism. Here, we investigate the mechanism of orbital selective switching of the spin-polarization in the oxide q2DEG formed at the (001) interface between the $LaAlO_3$, $EuTiO_3$ and $SrTiO_3$ band insulators. By using density functional theory calculations, transport, magnetic and x-ray spectroscopy measurements, we find that the filling of titanium-bands with $3d_{xz}/3d_{yz}$ orbital character in the $EuTiO_3$ layer and at the interface with $SrTiO_3$ induces an antiferromagnetic to ferromagnetic switching of the exchange interaction between Eu-$4f^7$ magnetic moments. The results explain the observation of the carrier density-dependent ferromagnetic correlations and anomalous Hall effect in this q2DEG, and demonstrate how combined theoretical and experimental approaches can lead to a deeper understanding of emerging electronic phases and serve as a guide for the materials design of advanced electronic applications.

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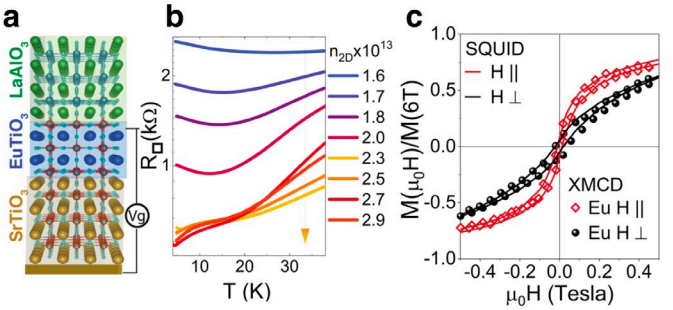

Fig. 1: (a) Sketch of the LAO/ETO/STO heterostructure. (b) Sheet resistance vs. temperature as a function of the gate voltage Vg. The arrow indicates increasing values of Vg from −30 to 30 V and 2D carrier density. (C) Eu- XMCD (scatter data) and SQUID magnetization (continuous lines) as function of the magnetic field parallel (red) and perpendicular (black) to the interface. The data are normalized to the saturation value.

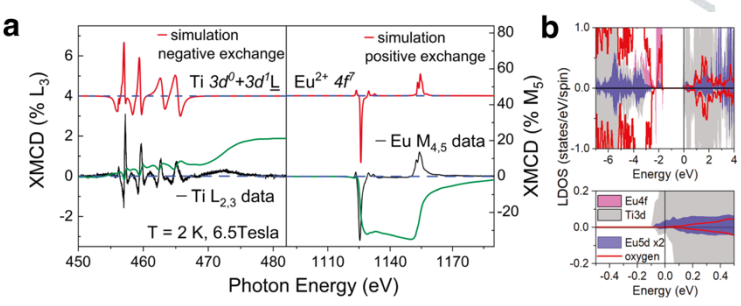

Fig. 1: (a) XMCD data at the Ti-L (left) and Eu-M (right) edges at 6.5 Tesla and 2 K. Red-lines are atomic multiplet simulations, green lines are integrals of the XMCD spectra. (b) Spin-resolved band structure and LDOS in the AFM state from the DFT+U calculations. Element and spin-resolved density of states from the DFT+U calculations for $EuTiO_3$ layers (average) with FM coupling. In the FM solution we do observe a substantial spin-polarization at −2 eV of both Eu-4f (magenta) and Eu-5d (blue) states, and an overlap between Ti-3d states (gray).