Highlights

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Dirac-like fermions anomalous magneto-transport in a spin-polarized oxide two-dimensional electron system

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In two-dimensional electron systems (2DESs), the breaking of the inversion, time-reversal and bulk crystal-field symmetries intertwines with the spin-orbit coupling (SOC), giving rise to exotic quantum phenomena. By engineering a spin-polarized oxide 2DES with Rashba-like SOC and hexagonal band warping, here we present the first report of an anomalous quantum correction to the magnetoconductance, originating from Dirac-like fermions experiencing competing weak anti-localization and weak localization back-scattering (Fig. 1(a) and ref. [1]). This phenomenology closely resembles that of gapped topological insulators. The results were obtained on the 2DES formed at the epitaxially grown interfaces between (111) $LaAlO_3$, $EuTiO_3$, and $SrTiO_3$ single crystal, characterized by a trigonal crystal field splitting and ferromagnetism induced by Eu and Ti ions magnetic ordering. Notably, the anomalous magnetoconductance disappears at the magnetic critical temperature, showing a direct link with the ferromagnetic order. The data are explained theoretically in a single band scenario as the combined effects of the Rashba-SOC, of the band-warping induced by the 2DES trigonal symmetry, and of the magnetic gap opening at spin-orbit induced Dirac-like point, giving rise to a non-trivial Berry phase (fig. 1(b, c)). These findings open perspectives for the engineering of novel spin-polarized functional 2DES holding promises in spin-orbitronics and topological electronics.

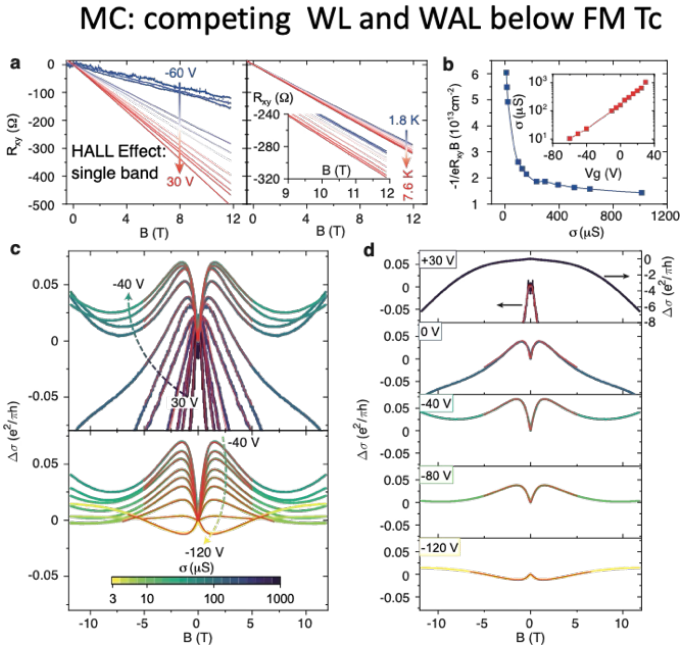

Figure 1 : a) Gate voltage (at 1.8 K) and temperature (at Vg = –10 V) dependence of the Hall effect on a Hall-bar oriented along the [̄110] crystallographic direction. The inset is a zoomed-in view. b) Gate voltage dependence of the inverse Hall coefficient and sheet conductance. c) MC as function of gate voltages in the range +30 V to –40 V (upper panel) and –40 V to –120 V (lower panel). The color-code of each MC data corresponds to the sheet conductance shown in the colorbar ($\sigma \approx 1$ mS – 2.9 μS). Red lines are the best fits. d) Extracted MC data from the data set and their fits, at 30, 0, –40, –80, and –120 V, to highlight the evolution of the peak-shoulder feature as function of the gate voltage. The MC at +30 V in the full range is displayed in the right axis.

References

[1] Y. Chen, et al., Adv. Mater. 37, 2410354 (2025)

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