Quantum interference at the $(La_{0.3}Sr_{0.7})(Al_{0.65}Ta_{0.35})O_3/SrTiO_3$ interface

K. Rubi,[1] **K. Han**,[2] **H. Zhen**,[2] **M. Goiran**,[3] **D. Maude**,[3] **W. Escoffier**,[3] **and A. Ariando**[2]

[1] *National High Magnetic Field Laboratory, Los Alamos National Laboratory, USA*
[2] *Department of Physics, National University of Singapore, Singapore*
[3] *Laboratoire National des Champs Magnétiques Intenses (LNCMI-EMFL), France*

Quantum interference – whether observed in the form of Aharonov-Bohm effect, the Altshuler–Aronov–Spivak effect, or quantum conductance fluctuations – offers valuable insights into electron dynamics within an electromagnetic environment. These phenomena allow direct measurement of the phase coherence length, which is critically important for developing quantum technologies such as quantum sensing, quantum computing, and quantum communication.

We report quantum oscillations in magnetoresistance that are periodic in magnetic field (B), observed at the interface between $(La_{0.3}Sr_{0.7})(Al_{0.65}Ta_{0.35})O_3$ and $SrTiO_3$ [1]. Unlike Shubnikov–de Haas oscillations, which appear at magnetic fields > 7 T and diminish quickly as the temperature rises, these B-periodic oscillations emerge at low fields and persist up to 10 K. Their amplitude decays exponentially with both temperature and field, specifying the dephasing of quantum interference. Increasing the carrier density through electrostatic gating results in a systematic reduction in both the amplitude and frequency of the oscillations, with complete suppression beyond a certain gate voltage. We attribute these oscillations to the Altshuler–Aronov–Spivak effect, likely arising from naturally formed closed-loop paths due to the interconnected quasi-one-dimensional conduction channels along $SrTiO_3$ domain walls. The relatively long phase coherence length (~ 1.8 μm at 0.1 K), estimated from the oscillation amplitude, highlights the potential of complex oxide interfaces as a promising platform for exploring quantum interference effects and advancing device concepts in quantum technologies, such as mesoscopic interferometers and quantum sensors.

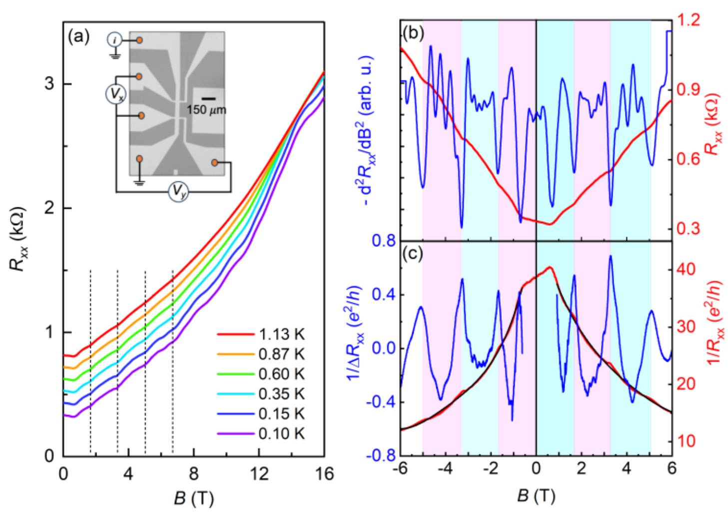

Figure 1. (a) Magnetic field dependence of longitudinal resistance at a few selected temperatures. The B-periodic oscillations in low fields are depicted by vertical dashed lines. Inset is an optical microscope image of the Hall-bar device. (b) A second order derivative of resistance reveals B-periodic oscillation along with higher harmonics. (c) B-periodic oscillations in conductance.

[1] K. Rubi *et al.*, arXiv:2508.09013 (2025).

+ Author for correspondence: rubi@lanl.gov