Magnetotransport in Nanostructures at the LaAlO$_3$/SrTiO$_3$ Interface

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Introduction
A nanoscale metal-insulator transition at LaAlO$_3$/SrTiO$_3$ (LAO/STO) interfaces can be controlled by conductive atomic force microscope (AFM) [1,2]. Taking advantage of the low dimensionality and controllable transport parameters, we proposed to investigate quantum transport effects at high magnetic fields and low temperatures.

Experimental
Several different nanostructures at LAO/STO interface were prepared using AFM lithography technique as described in Ref. [1,2]. Magnetico transport measurements were performed using facilities in magnet lab including He3 system with 18 T superconducting magnet (SCM2), dilution refrigerator with 18 T superconducting magnet (SCM1) and He3 system with 35 T resistive magnet (Cell 12).

Results and Discussion

![Figure 1](image_url)

Interfacial nanostructures were made with carrier density and mobility partially controlled by the channel geometry and AFM writing conditions. Integer and fractional quantum Hall states were observed in a Hall bar structure composed of nanowires of widths 14 nm and a carrier density of 8×10$^{11}$ cm$^{-2}$ (Fig.1A). Anomalous Hall effect, including plateaus in the Hall conductance, was observed in a 6 nm wide Hall cross with carrier density 2×10$^{12}$ cm$^{-2}$ (Fig.1B). In a similar structure with higher carrier density, Shubnikov-de Haas oscillations were observed at magnetic fields up to 35 T (Fig.1C). High magnetic fields are required because of the large effective mass (m*~5m) and relatively high sheet densities. Evidence for strong spin-orbit coupling comes from observations of weak antilocalization (Fig.1D).

Conclusions
Magneto transport experiments in LAO/STO interfacial nanostructures carried out at NHMFL revealed a rich variety quantum transport phenomena which we are trying to interpret and understand. Future proposed experiments will incorporate direct control over carrier density, which will help us to gain new insight into this new and interesting physical system.

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References