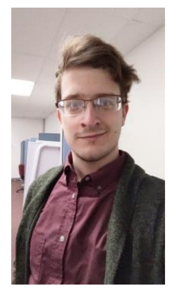
Large Magnetoresistance and Quantum Oscillations in $Sn_{0.05}Pb_{0.95}Te$



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Background

Topological Insulators are very new and interesting materials due to their highly conducting surface states arising from the non-trivial bulk topology. They have the potential to be used in a variety of areas such as highly efficient electronics and possibly quantum computers. Here, we have studied magnetotransport properties of $Sn_xPb_{1-x}Te$, known as a Topological Crystalline Insulator.

Methods

Synthesized High-quality $Sn_xPb_{1-x}Te$ Single Crystals → Performed High-magnetic Field measurements (13 T) at temperature 4.2 K → Analyzed data using -Fourier Transform -Landau Level fan plot → Determined the Fermi surface Topology

Results

Figure 2 describes longitudinal (R_{xx}) and Hall resistance (R_{xy}) under high magnetic fields up to 13 T at 4.2 K. At high fields, both R_{xx} and R_{xy} show oscillations, known as Shubnikov de-Haas (SdH) oscillations. The oscillations are clearly visible in the background subtracted data (insets).

Figure 3 shows the frequencies of SdH oscillations at different tilt angle (θ) of the magnetic field. There exists mainly two frequencies (f_α and f_β).

Figure 4 shows the Landau level fan plot for $Sn_{0.05}Pb_{0.95}Te$ single crystal. The maxima and minima positions are assigned as integer and half-integer numbers, respectively. From the linear extrapolation, we observed the Berry phase ~ 0.1, which is close to 0 (expected for a topological trivial system).

- A topological Insulators is a new quantum state of materials with an insulating bulk and highly conducting surface.
- The bulk has a trivial insulating bands, whereas the surface has a linear band structure as shown in Fig. 1.
- We synthesized high-quality single crystals of $Sn_xPb_{1-x}Te$.
- Our magnetotransport data reveal the trivial topology (not a TI) of $Sn_{0.05}Pb_{0.95}Te$.

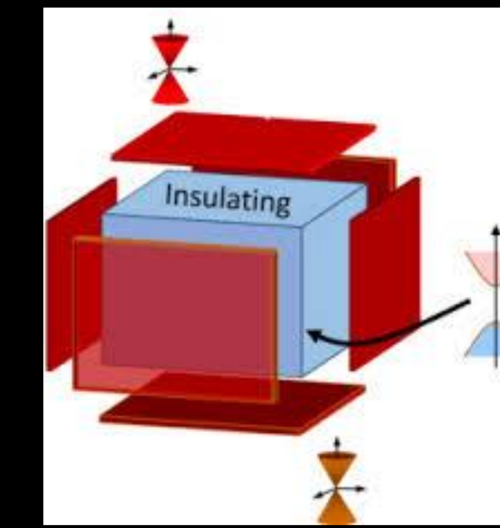


Fig. 1. A schematic diagram for a topological insulator showing the bulk and surface along with their band structure.

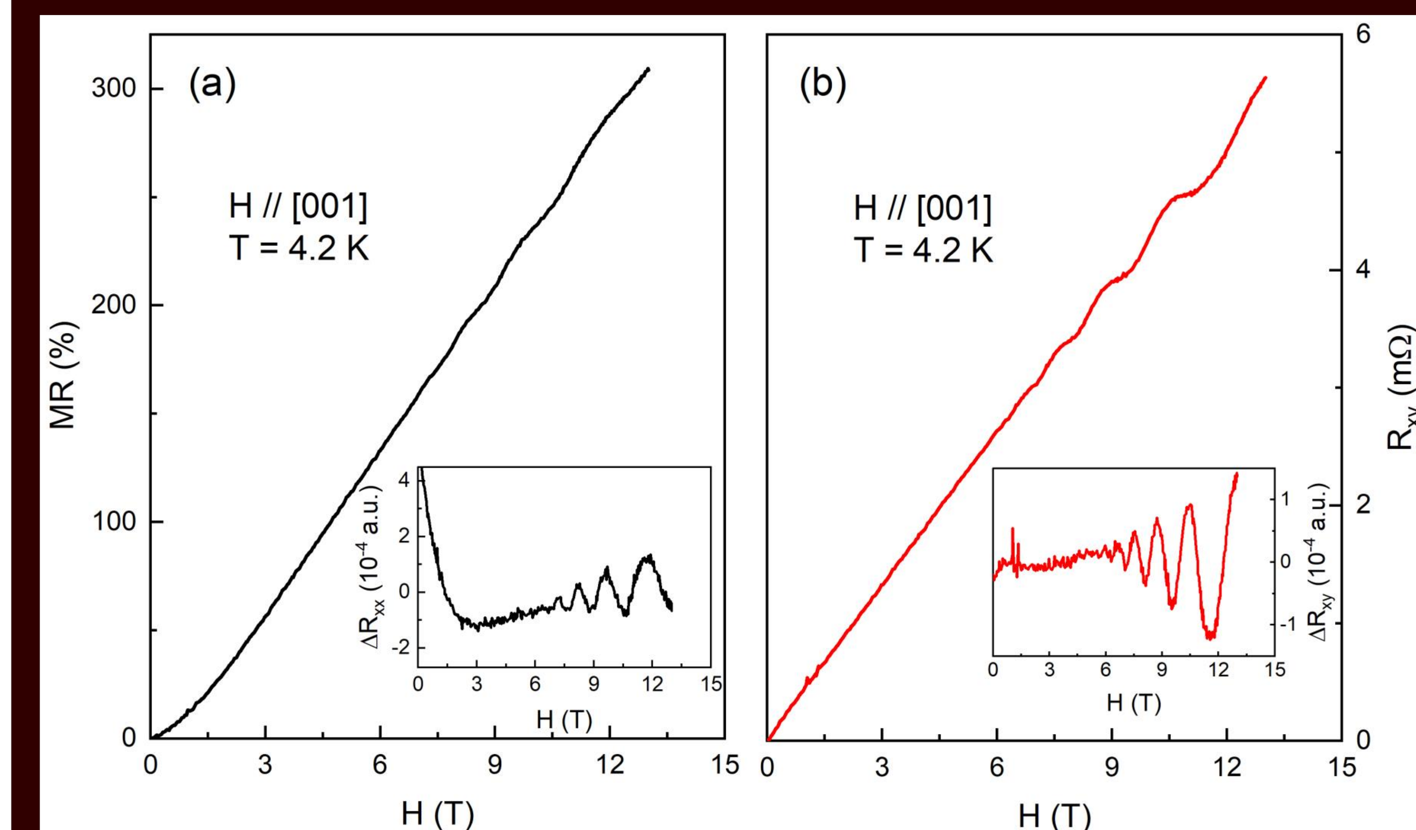
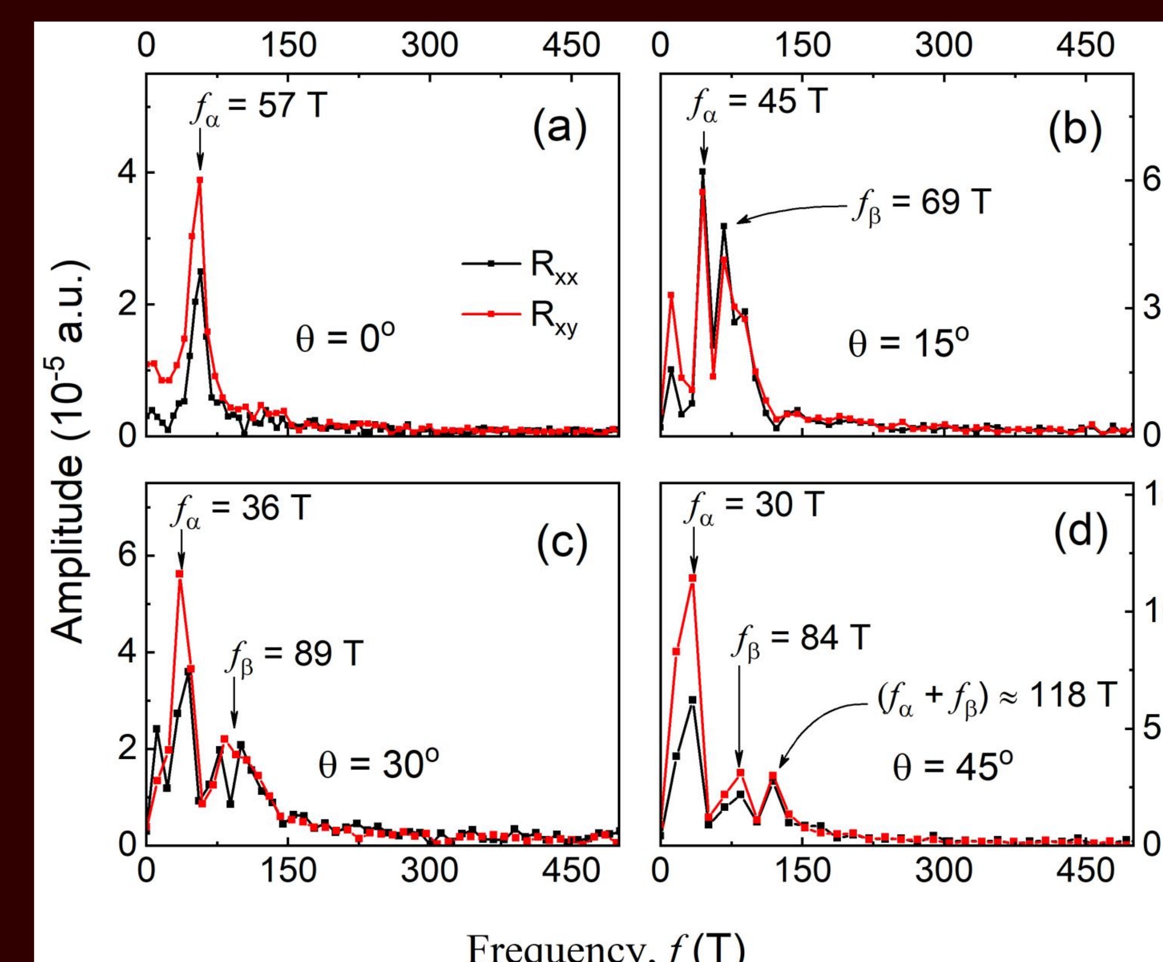


Figure 2: Magnetoresistance and Quantum Oscillations. (a) Magnetoresistance (MR) expressed as a percentage and (b) Hall resistance (R_{xy}) of single-crystal $Sn_{0.05}Pb_{0.95}Te$ as function of applied field (H). MR is positive and reaches ~310 % under an applied field of 13 T at 4.2 K. The positive slope of the R_{xy} vs. H plot indicates the presence of hole-like bulk charge carriers. Both MR and R_{xy} show a signature of quantum oscillations at higher fields that is clearly observed in the polynomial background-subtracted data, as shown in the insets to (a) and (b), respectively. The oscillations are periodic and appear to have a single frequency.

Figure 3: Frequency Plot at Higher Angles. Fourier transforms of quantum oscillations for both longitudinal and Hall resistance at θ values of (a) 0°, (b) 15°, (c) 30°, and (d) 45°.The frequency values obtained from oscillations in longitudinal and transverse resistance are comparable to one another. At θ = 0°, there exists only one frequency. The number of frequencies increases at higher angles, suggesting the existence of more than one Fermi wave vector.



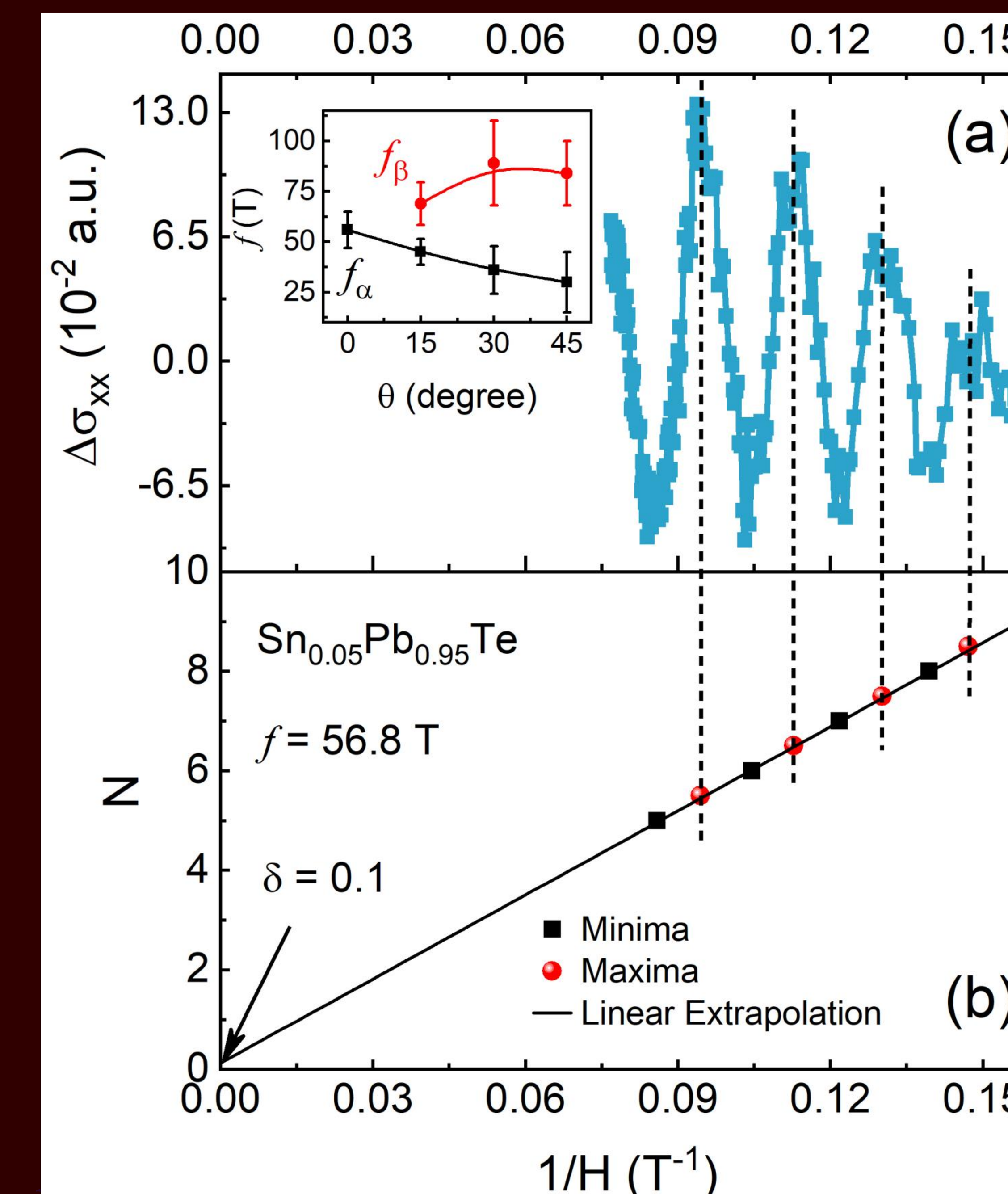


Figure 4: Berry Phase Analyses. (a) Quantum oscillations after background subtraction at θ = 0°. Inset: angle dependence of frequencies f_α and f_β from Fig. 5. The error bar for each data point is defined as the half-width at half height of the respective peak in the frequency plot [Fig. (3)]. (b) Landau-level fan diagram constructed using maxima and minima of the oscillations in (a). From the linear extrapolation, the Berry phase and frequency values are found to be δ = 0.1 and f_α = 56.8 T, respectively.

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