Tunable Weyl Fermions in Chiral Tellurene in High Magnetic Fields

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Atomically-thin, two-dimensional tellurene films were grown and fashioned into an n-type doped Hall bar device at Purdue. Electron transport measurements down to 0.3 K were made in the MagLab's unique 45T hybrid magnet. Well-developed quantum Hall states up to a filling factor of $\nu = 2$ showed a strong gate dependence as a direct consequence of tellurene's semiconducting nature (see Fig 1). *The quantum Hall sequences for ten different densities (Fig 2) revealed a π Berry phase offset, a smoking gun for Weyl fermions with non-trivial topological properties.*

In many Weyl semimetals, Weyl fermions arise from an accidental band-crossing that gives rise to a fixed, small bandgap. The carrier density is also fixed, which hampers the ability to tune the low-energy relativistic quasiparticles of interest. In this experiment, by realizing a high-quality tellurene film, researchers observed the quantum Hall effect under high magnetic fields. *Furthermore, their fabrication of an electrostatic-gate-tunable device enabled multiple and, hence, unambiguous measurement of the topologically non-trivial Berry phase caused by unconventional Weyl nodes which originate from the chiral structure in this novel two-dimensional system.*

Crystals with a chiral structure and strong spin-orbit coupling can host Weyl nodes protected by their screw-shaped symmetry, which has distinctive band features differing from conventional Weyl nodes, resulting in a hedgehog-like spin texture. *This experiment demonstrates that chiral Weyl nodes can locate at the band edges of a semiconductor, allowing for great tunability to explore Weyl physics and design quantum devices.*

Facility used: 45 Tesla Hybrid Magnet in DC Field Facility
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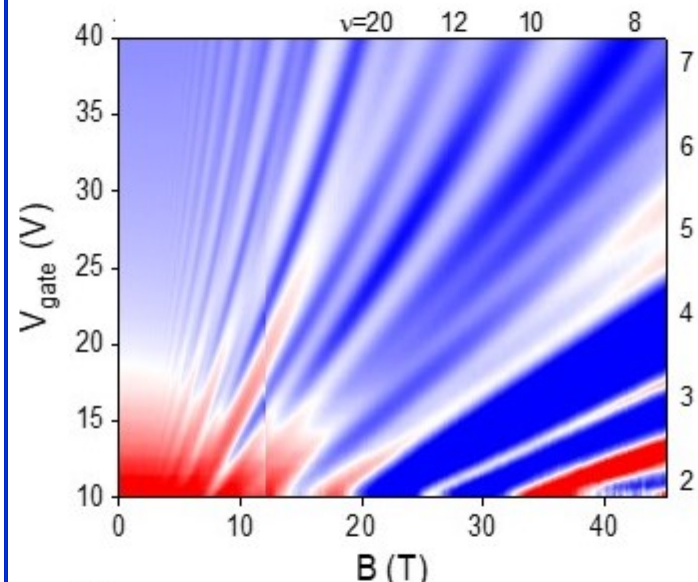

Fig 1: Oscillating longitudinal resistance of a tellurene film with well-defined quantum Hall states for filling factors from $\nu = 20$ to $\nu = 2$ that are tunable by an applied gate voltage.

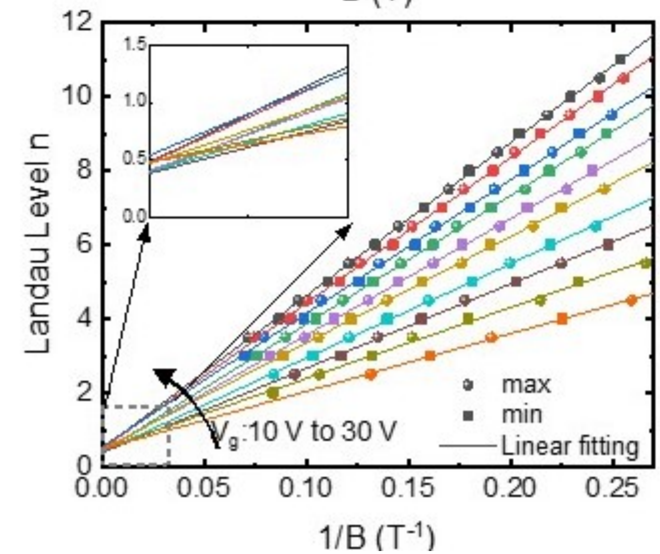

Fig 2: Extracting a non-trivial π Berry phase from the quantum oscillation offset equaling 0.5 in n-type tellurene Note that the data are expanded to show the offset in the figure inset.