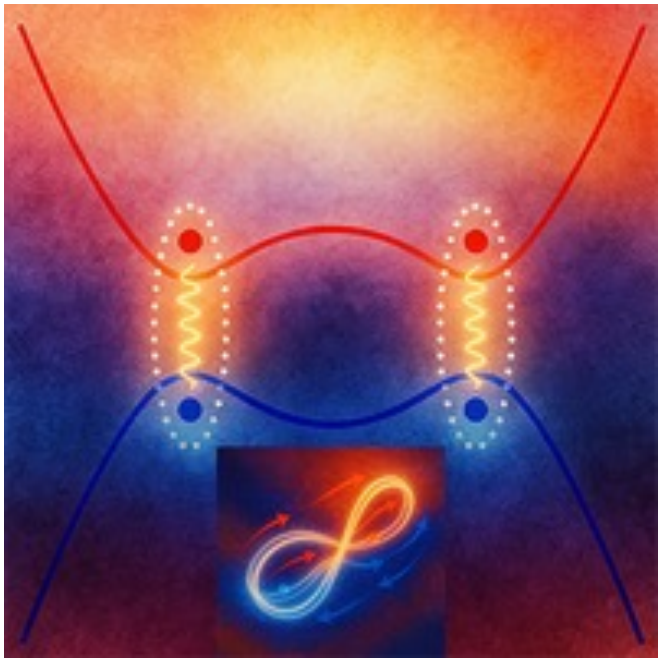
# Spin-Triplet Excitonic Insulator in the Ultraquantum Limit of $HfTe_5$



Liu, J.; Subramanyan, V.; Welser, R.; McSorley, T.; Ho, T.; Graf, D.; Pettes, M. T.; Saxena, A.; Winter, L. E.; Lin, S.-Z.; Jauregui, L. A. Possible Spin-Triplet Excitonic Insulator in the ULTRAQUANTUM Limit of . *Physical Review Letters* **2025**, *135* (4). DOI:10.1103/bj2n-4k2w.

## Scientific Achievement

Discovery of a spin-triplet excitonic insulator phase in the ultraquantum limit of $HfTe_5$. This quantum phase emerges due to magnetic-field-induced pairing between spin-polarized electrons and holes, resulting in a charge-neutral, gapped state observable via magnetotransport.

## Significance and Impact

This work provides the first experimental evidence of a spin-triplet excitonic insulator in a 3D topological material. It introduces a promising platform for exploring spin superfluidity, spin-based Josephson effects, and applications in quantum spintronic devices.

## Research Details

- Performed magnetotransport measurements under fields up to 72 T revealing a ~250 μeV gap and zero Hall conductivity.
- Observed nonlinear transport and negative longitudinal magnetoresistance indicative of a 1D Weyl phase.
- Theoretical modeling confirms spin-triplet exciton formation between oppositely polarized zeroth Landau levels. The excitonic gap and its BCS-like temperature dependence validate the excitonic insulator scenario.

Work was performed, in part, at the Center for Integrated Nanotechnologies.