

## Landau-level spectroscopies on topological insulators

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Dirac fermions at the surfaces of topological insulators may bring about unique quantum phenomena in a magnetic field. We studied Landau quantization of Bi<sub>2</sub>Se<sub>3</sub> using a high-field scanning tunneling microscopy/spectroscopy. Bi<sub>2</sub>Se<sub>3</sub> is regarded as a typical topological insulator but real material is doped with bulk electrons associated with Se vacancies. In a magnetic field perpendicular to the cleaved surface, we succeeded in observing a series of Landau levels with a field-independent level at the Dirac point, which is a hallmark of Dirac fermions. Landau orbits in real space are localized either around potential maxima or minima depending on energy as expected in quantum Hall systems. We also studied Sb<sub>2</sub>Te<sub>2</sub>Se which is naturally doped with bulk holes. We found that the Landau level at the Dirac point exhibits large Zeeman shift ( $g \sim 20$ ), indicating that magnetic properties of Dirac surface state is highly material dependent.