Controlling topologically protected states by external fields and doping
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Motivation: Topologically protected surface states are foreseen to boost and reshape the current paradigm of electronics, spintronics, photonics and many other areas alike. It is therefore desirable to have a full control of their defining properties.

Systems: Three-dimensional topological insulators (e.g., Bi₂Se₃) and topological crystalline insulators (e.g., SnTe).

Main Results: External electric and magnetic fields allow to dynamically modify the Fermi velocity. δ-doping induces a coexistence between a Rashba 2DEG and the topological surface states, altering the optical transitions.

Topological Boundary

Electric Field

Anisotropic Fermi velocity reduction
\[ \frac{v_F(F)}{v_F(0)} = 1 - \frac{5F^2}{8F_c^2} \]
\[ \delta F_c d = \Delta \]
\[ d = \frac{\hbar v_F}{\Delta} \]

Magnetic Field

\[ b = 0 \]
\[ b \neq 0 \]
\[ \ell_B = \sqrt{\frac{\hbar}{eB}} \]

Crossed Fields

Spectrum

Topological

States

Optical Transitions

Conclusions

- Topological surface states are robust against perturbations.
- Dirac dispersion can be modified externally.
- Rashba-like 2DEG coexists with topological surface state.
- Linear optical response is reshaped by the topological state.

References

- Topological Boundary:
  - Volkov and Pankratov, JETP Lett. 42, 178 (1985)
  - F. Zhang et al., PRB 86, 081303 (2012)

- External Fields:
  - A. Díaz-Fernández et al., BJNANO 9, 1405 (2018)

- δ-doping:

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