Tailoring Fermi's velocity in topological insulators by an electric field

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Combined with band-engineering techniques, topological insulators could dramatically boost and reshape the current state-of-the-art in electronics. Parameters such as the Fermi velocity are of great relevance to this issue, and their flexible manipulation would allow to largely broaden the spectrum of possibilities. So far, however, changes in the Fermi velocity require very cumbersome setups, making them rather unpractical for real applications [1-3].

In this work, I will present a theoretical mechanism that enables to tailor Fermi's velocity avoiding both structural and configurational alterations. Despite of being a theoretical prediction, it can be readily achieved experimentally. The system at hand is a double-gated band-inverted junction. Here, a heterostructure is built by growing a band-inverted semiconductor, followed by a conventional semiconductor, thus forming a sharp junction (attainable by molecular beam epitaxy techniques) where the aforementioned edge states take place. A two-band Dirac model has proven to be the most suited one for describing the electronic states of these systems [4-5]. This model allows us to consider a uniform electric field (achievable by means of front- and back-gates) and is exactly solvable, as we have shown [6]. However, one can gain further intuition by applying some reasonable approximations that lead to our main result: Fermi's velocity can be substantially lowered, becoming a tunable parameter. This result matches the exact calculations in the experimentally feasible range of fields considered for the approximation. Hand-waving arguments capture the essential physics and are summarized in Figure 1.

References

[1] G. Li et al., Nat. Phys. **6** (2010) 109.
[2] G. Trambly de Laissardière et al., Nano Letters **10** (2010) 804.
[3] D. C. Elias et al., Nat. Phys. **7** (2011) 701.
[4] B. A. Volkov and O. A. Pankratov, Sov. Phys. JETP **42** (1985) 178.
[5] F. Domínguez-Adame, phys. stat. sol. (b) **186** (1994) K49.
[6] A. Díaz-Fernández et al., submitted for publication.

Figures

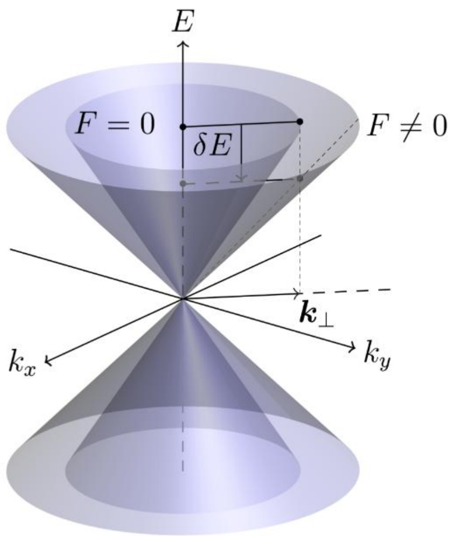

Figure 1. Dirac cones of the edge states at zero and finite electric field F, applied perpendicular to the interface. By adiabatically switching on the electric field, there is a decrease of the electron energy of magnitude δE. Since the interface momentum $\boldsymbol{k}_\perp$ is conserved, the cone must then widen, thus leading to an effective reduction of Fermi's velocity.