Propagation of electromagnetic radiation in a slab waveguide with topological insulator walls

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The topological magnetoelectric effect emerges whenever time reverse symmetry is broken at the surface of three-dimensional topological insulators (3D TI, like Bi_2Se_3, Bi_2Te_3 and Sb_2Te_3 compounds) in the long-wavelength regime of electromagnetic (EM) radiation [1]. As consequence, the EM response of 3D TIs is given in terms of fine structure constant due to the quantized Hall current excited on the 3D TI surface by a parallel electric field [2,3]. Among other consequences, when light is sent to a TI border, its behavior is deeply modified: for instance, light plane polarization is rotated by a universal angle leading to unusual Kerr/Faraday and EM scattering effects [4].

Here, we shall show that whenever light propagation is guided by 3D-TI walls, it experiences a cutoff frequency coming from topological grounds, ω_θ, which is related to the penetration length of metallic surface states into the TI-bulk, l. The scenario is such that lower frequencies, $\omega_\theta < \omega$, are reflected by the walls, while for $\omega_\theta > \omega$ considerable part of the incident light penetrates into the TI-bulk making wave propagation throughout the waveguide deeply jeopardized. Our findings suggest that TI-made waveguides enable an estimate of the microscopic quantity, l, by measuring the topological optical response carried out by the macroscopic signature of ω_θ [5]. Furthermore, such topological stability can be useful in waveguides to propagate EM radiation in scattering light experiments and applications [6].

References

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