Terahertz harmonic generation in topological insulators

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Terahertz (THz) technology can boost abundant promising optoelectronic applications. High power efficiency and low energy consumption are critical for the development of intelligent, dynamic and sustainable THz communication and sensing for 6G and beyond. Massless Dirac fermions possess extremely large THz nonlinear susceptibilities and harmonic conversion efficiencies. Indeed, the record value for the THz harmonic efficiency has been reported for graphene several years ago. However, the generated harmonic intensity is limited due to the efficiency saturation with increasing THz power. High-quality, high-mobility Bi_2Se_3 topological insulators (TIs) demonstrates an improvement by two orders of magnitude compared to the record value in a benchmarked graphene sample at room temperature. This exceptional performance is the result of thermodynamic harmonic generation by the massless topological surface states, benefiting from ultrafast dissipation of electronic heat via surface-bulk Coulomb interactions. Furthermore, HgTe-based TIs reveal strong THz nonlinearity. Systematic measurements on the serious of HgTe samples corresponding to three qualitatively different cases – 2D trivial and topological structures and 3D topological insulators – provides insight into physical mechanisms leading to high harmonic generation in TIs.