Optics of two-dimensional materials hosting tilted Dirac cones

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We analyse the interband optical absorption of linearly polarised light by 2D Dirac semimetals hosting tilted Dirac cones in the band structure [1]. Super-critically tilted (type-II) Dirac cones are characterised by an absorption that is highly dependent on incident photon polarization and tuneable by changing the Fermi level with a back-gate voltage. Unlike their sub-critically tilted (type-I) counterparts, type-II Dirac cones have open Fermi surfaces meaning that there exist large regions of the Brillouin zone where both bands sit either above or below the Fermi level causing many states that would otherwise contribute to absorption to be Pauli blocked. We analyse Dirac cones featuring tilt as well as anisotropy in the Fermi velocity, yielding a wide range of qualitatively unique absorption spectra. Guided by our in-depth discussion we develop an optical recipe to fully characterise the tilt and Fermi velocity anisotropy of any 2D tilted Dirac cone solely from its absorption spectra. We also show that tilted Dirac cones allow spatial separation of carriers belonging to two different valleys under illumination by linearly polarized light, leading to novel optovalleytronic applications. Our results are used to analyse polarisation-dependent light absorption of 8-Pmmn borophene [2,3].

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