Optics of solids with relativistic-like electrons

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The fabrication of graphene in 2004 [1] and the subsequent discovery of massless electrons [2,3] within its electronic band structure is nowadays viewed as a crucial advance for the whole solid-state physics. The existence of this first truly two-dimensional crystal, together with the astonishingly simple way of its preparation via micromechanical cleavage (exfoliation), opened the way towards an entirely new class of 2D materials [4] which nowadays comprises a large number of members with insulating, semiconducting, metallic or even superconducting character. The experimental observation of conical features in the graphene's band structure – giving rise to an appealing analogy between condensed-matter and high-energy physics – had an equally important impact. It triggered, in the end very successful, search for other systems hosting massless, or more generally, relativistic-like charge carriers. These were found, for instance, in topological and topological crystalline insulators [5,6], in semiconductors with a giant Rashba-type spin splitting [7] or most recently, in three-dimensional Dirac and Weyl semimetals [8,9], thus forming unusually rich playground for fundamental but also applied physics. In my talk, I will review the physics of 2D and 3D materials beyond graphene and particular attention will be devoted to their optical and magneto-optical properties.

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