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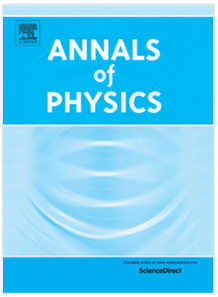

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Dynamical centrosymmetry breaking — A novel mechanism for second harmonic generation in graphene

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Abstract

We discover an unusual phenomenon that occurs when a graphene monolayer is illuminated by a short and intense pulse at normal incidence. Due to the pulse-induced oscillations of the Dirac cones, a dynamical breaking of the layer's centrosymmetry takes place, leading to the generation of second harmonic waves. We prove that this result can only be found by using the full Dirac equation and show that the widely used semiconductor Bloch equations fail to reproduce this and some other important physics of graphene. Our results open new windows in the understanding of nonlinear light-matter interactions in a wide variety of new 2D materials with a gapped or ungapped Dirac-like dispersion.

Keywords: PACS numbers: 42.65.-k Nonlinear optics; 42.65.Ky Frequency conversion; harmonic generation, including higher-order harmonic generation; 42.65.Sf Dynamics of nonlinear optical systems; optical instabilities, optical chaos and complexity, and optical spatio-temporal dynamics; 42.65.Wi Nonlinear waveguides

Introduction —. The physics of graphene and related materials has attracted a broad interest since the initial experimental realisation of graphene monolayers [1]. At relative low energies, graphene shows a unique Dirac-like band structure and this implies that quasielectrons behave as if they were massless Dirac fermions [2]. Due to this special property, graphene electronics is quite