Laser-induced Topological Phase in Graphene

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Abstract

We propose and theoretically explore reduced-symmetry (P- and T -broken) states of graphene superlattices created by strong circularly-polarized ultrashort pulses. The conduction-band electron distribution in the reciprocal space forms an interferogram with discontinuities related to topological (Berry) fluxes at the Dirac points. Our findings hold promise for control and observation of ultrafast electron dynamics in topological solids and may be applied to petahertz-scale information processing and ultrafast data storage devices.
One of the fundamental problems of topological physics of graphene is a direct observation of the Berry phase. This is related to the fact that the only realistic possibility of observing this phase is self-referenced interferometry of electronic waves in the reciprocal space. However, the Berry phase is $\pm\pi$; the self-referenced interferometry doubles it to $\pm 2\pi$, which does not produce any discontinuities in the interference fringes. The Bragg scattering from the superlattices creates diffraction and “which way” interference in the reciprocal space reducing the Berry phase and making it directly observable in the electron interferograms, which can be read-out with time- and angle-resolved photoelectron emission spectroscopy (TR-ARPES). These interferograms give the most direct information about such fundamental topological field as Berry curvature of the reciprocal space. The femtosecond dynamics of such interferograms will provide direct information about electron momentum relaxation in graphene.

Keywords—Graphene, topology, light-induced superconductivity, ultrafast data storage

Professional Biography

Hamed Koochaki Kelardeh has completed his PhD at the age of 31 years from Georgia State University and postdoctoral studies from the Center for Nano-optics (CeNO) at Georgia State University. He has published more than 20 papers in reputed journals and has been serving as an editorial board member of a number of journals.



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