MAR08-2007-001237

Abstract for an Invited Paper
for the MAR08 Meeting of
the American Physical Society

Veselago lens and p-n junctions in graphene.[1]

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Both monolayer and bilayer graphene are gapless semiconductors. Their electrostatic modulation can be used to generate single and multiple p-n junctions. We have shown [V. Cheianov and V.I. Fal'ko - Phys. Rev. Lett. 97, 226801 (2006)] that p-n junctions in monolayer graphene are transparent for incident electrons. In particular, those electrons approaching the n-p interface in an almost perpendicular direction can cross it without reflection. Moreover, in graphene the transmission of charge through the n-p interface is quite similar to the refraction of electromagnetic waves at the interface where the refractive index inverts sign [J. Pendry - Nature 423, 22 (2003); J. Pendry - Phys. Rev. Lett. 85, 3966 (2000)]. This is because the electron dispersion in the conduction and valence bands in graphene is such that so that, after an electron crosses the n-p interface, from the n- to p-side, its wave vector becomes directed opposite to its velocity. As a result, n-p junctions in graphene possess intriguing and very promising transport properties: a single straight p-n interface can focus electrons [V. Cheianov, V.I. Fal'ko, B.L. Altshuler - Science 315, 1252 (2007)]. This situation is realised in the n-p junction with equal densities of carriers in the n- and p-regions. Also, we have shown that by varying the carrier density in, e.g., p-side of the junction the focus can be smeared into a pair of caustics meeting each other in a cusp, and calculated the characteristic interference pattern of electron waves in the vicinity of the cusp. Using the idea of fine-tuned focusing of electron flow by the p-n interface, we propose to use n-p-n junction In a bipolar graphene-based transistor to create Veselago lens and focused beam splitters for electrons.

[1]I acknowledge support from EPSRC-UK, the Alexander von Humboldt Foundation and hospitality of Hannover University. This work has been started during the MPI Conference "Graphene Week 2006" at the Max-Planck-Institute for Complex Systems in Dresden.