Valley transport in graphene-based devices: Achieving directionality and quantifying polarization

M. Berdakin[1]
J. E. Barrios Vargas[1]
L. E. F. Foa Torres*[1]

1- Depto de Física, Fac. de Ciencias Físicas y Matemáticas, Universidad de Chile, Santiago, Chile.

*luisfoa@gmail.com

First isolated in 2004 by Nobel Laureates Andre Geim and Konstantin Novoselov, graphene has united many record electrical, mechanical, thermal and optical properties (see for example [1]). The most notable electrical properties stem from its peculiar bandstructure which close to the Fermi energy combines a linear cone-like dispersion with pseudo-spin-momentum locking, similar to that expected for massless relativistic particles. There are two inequivalent cones in the energy dispersion, thereby leading to a binary spin-like flavor which is called the valley (see Fig.1). The valley degree of freedom can be exploited for useful functions and may replace charge in low power applications. A fundamental challenge is the formulation of a valley-controlled valley polarization source, in which the polarization of the valley degree of freedom can be flipped. This type of switchable valley source of electrons are the cornerstone for the future development of new valleytronics devices [2,3]. Here we explore the generation of charge and valley polarized unidirectional transport in graphene bilayers. With this aim we build on previous proposals [4,5] and show how one-way ambipolar charge and valley transport can be achieved in graphene bilayers under experimentally feasible conditions. Furthermore we analyze the valley polarization robusteness among the presence of valley scatterers in the system. We also analyze the persistence of valley polarization currents in other already known polarizers.

References

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Figures

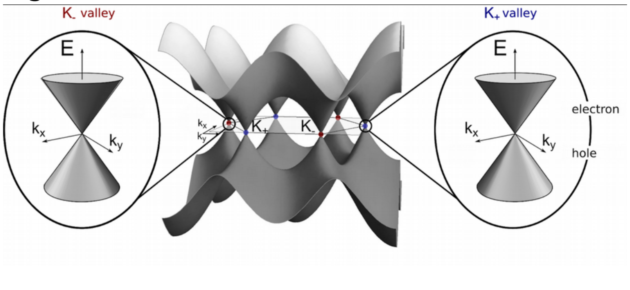

Figure 1: Scheme showing graphene's band-structure obtained using the simplest tight-binding model. There are two inequivalent points in the Brillouin zone where the conduction and valence meet denoted with K+ and K- and which define the graphene "valleys". Adapted from Foa Torres, Roche, and Charlier, "Introduction to Graphene-Based Nanomaterials", Cambridge University Press 2014.