Electronic Transport in Quasiperiodic Graphene p–n–p Junctions

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Abstract
Since the pioneering work of Novoselov *et al.* [1], graphene has been hailed as a promising candidate material for future microelectronic devices (for a review see [2]). Graphene is a sheet of crystal carbon that behaves as a ballistic conductor with a long mean free path that can be locally gated. In addition, graphene can carry spin currents, and supercurrents at room temperature. Although graphene is, in many respects, similar to carbon nanotubes, from the experimental standpoint the planar character of this material makes it more amenable to microelectronics and nanoelectronic applications. Hence, the researches about the electronic structure and electronic tunneling in arrangements of this material could affect the engineering of computers, mobile phones, security devices and medical applications devices [3].

On the other hand, the interaction of carriers with electrostatic barriers in this system is strongly influenced by Klein tunneling (i.e. the perfect transmission of carriers through potential barriers at normal incidence). This effect has been studied for periodic potentials and the effect of disorder on the charge transport through multiple barriers has been considered. These results have highlighted the interplay between disorder and resonance effects on the carrier transmission through multiple barriers, which can influence the overall conductivity of graphene-based devices [4].

In this work we investigate the interaction of charge carriers in graphene with a series of p–n–p junctions arranged according to a deterministic quasiperiodic substitutional Fibonacci sequence. Quasiperiodic systems are structures that can be classified as intermediate between ordered and disordered systems. Among the examples of quasiperiodic systems are artificial nanostructured materials with deterministic disorder, whose dynamic properties have common features, such as a fractal Cantor-like spectrum of elementary excitations.

The quasiperiodic sequence of p–n–p junctions in graphene gives rise to a potential landscape with quantum wells and barriers of different widths, allowing the existence of quasi-confined states. Spectra of quasi-confined states are calculated for several generations of the Fibonacci sequence as a function of the wavevector component parallel to the barrier interfaces. Our results show that, as the Fibonacci generation is increased, the dispersion branches form energy bands are distributed as a Cantor-like set (see Fig. 1). Besides, we obtain the electronic tunneling probability as a function of energy, whose transmission peak for small incidence angles is typical of Klein tunneling. The angular dependence of the transmission spectra is shown in Fig. 2 for carriers with energy E = 50 meV and potential barriers, whose height is U_0 = 100 meV. Observe that, in addition to the large transmission peak for small incidence angles, the presence of a large number of sharp peaks, which arise due to resonance effects. As the generation number increases, there is also an increase in the density of these transmission peaks, due to the resonant coupling with the bands of quasibound states in the structures.

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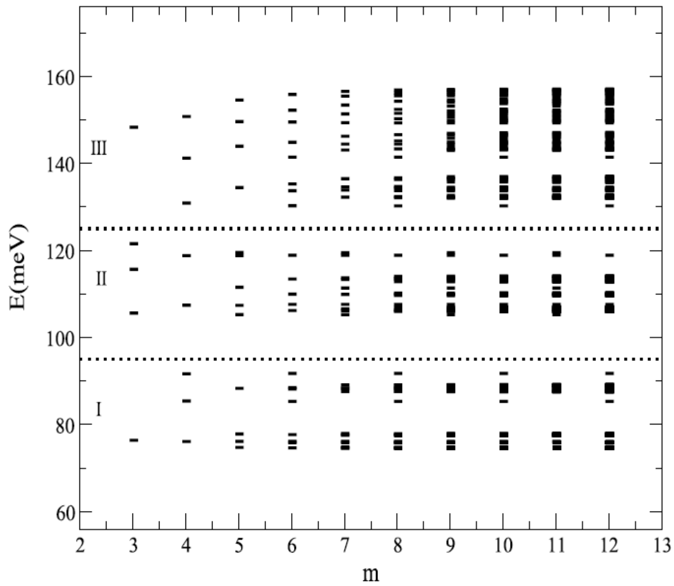

Figure 1: The distribution of the energy levels for the quasiperiodic graphene p–n–p Fibonacci structure (12th generation) as a function of the generation number *m* for the y-component wavevector $k_y = 0.11$ nm^{-1}.

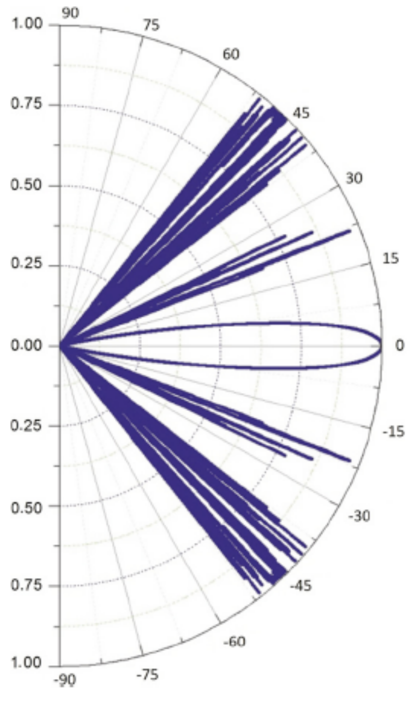

Figure 2: Angular dependence of the transmission for a quasiperiodic graphene p–n–p structure, corresponding to the 12th Fibonacci generation, for E = 50 meV and U_0 = 100 meV.