Spin-orbit coupling and spin relaxation times in sp^3-like distorted graphene

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Graphene is considered as a potential material for spintronics. The spin-orbit (SO) coupling in graphene is expected to be weak due to the low mass of the carbon atom. Besides this, the intrinsic SO coupling between flat graphene π electrons, which are the relevant ones in what concerns to transport properties, is a second order process since it involves virtual transitions into σ states [1]. However, the measured spin diffusion lengths [2] are much shorter than the expected ones [3].

Recently, longer spin lifetimes have been reported in monolayer and bilayer graphene spin valves [4]. The results of this work, which shows how the spin lifetime is longer in bilayer graphene than in monolayer, when the effective SO coupling between electrons is higher in the bilayer case due to the non-zero hoppings between π and σ orbitals in next-nearest neighbor atoms of different layers [5], suggest an extrinsic source of spin scattering, as impurities or other lattice defects.

In this work we analyze the enhancement of the SO coupling induced by a sp^3-like distortion of the sp^2 graphene lattice. Such kind of distortion can be produced by adatoms as hydrogen [6]. This perturbation mixes π and σ states, so the SO coupling in this system is a first order process. The effect of such kind of defects in spin relaxation is investigated as due to the Elliot-Yafet mechanism produced by the enhancement of the SO coupling.

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