Spin Hall effect in graphene with fluctuating Rashba field

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The crucial issue of spintronics is pure electrical control of the spin degree of freedom. One of the phenomena allowing such a control is the spin Hall effect (SHE) [1, 2], that originates from spin-orbit coupling in the system and leads to spin current (or spin accumulation) flowing perpendicularly to an external electric field. The spin Hall effect strongly depends on the type of spin-orbit coupling and may be either of intrinsic or extrinsic origin. The extrinsic SHE is associated with scattering mechanisms (skew scattering and side jump) on impurities and other defects, while the intrinsic SHE is a consequence of a nontrivial trajectory of charge carriers in the momentum space due to the spin-orbit contribution of a perfect crystal lattice to the corresponding band structure [3].

In a general case, local imperfections of the system, such as random distribution of donors or impurities, may lead to local enhancement or suppression of the spin-orbit coupling. Thus, charge carriers in the system propagate in an effective spin-orbit field that contains regular and random components. Such fluctuations significantly affect spin transport leading, for example, to strong modification of the spin relaxation as well as to spin Hall effect robust to impurity scattering [4, 5, 6]. A good example of systems with random spin-orbit field is graphene, in which the spatially fluctuating spin-orbit coupling may be due to ripples of the graphene plane, disorder, electron-phonon coupling in the substrate, the presence of adatoms, etc.

We will present results of our theoretical investigation of the spin Hall effect in graphene due to fluctuating Rashba field [7]. Using the Green function method and diagrammatic technique we have calculated the SHE conductivity of graphene in the situation when the Rashba interaction fluctuates around zero average value. The results show that potential scattering due to defects suppresses the spin Hall effect, but this suppression is not complete. The spin Hall conductivity in this case is generally not universal, but depends on the ratio of the total momentum and spin-flip relaxation rates. Thus, the behavior of spin Hall conductivity in graphene with fluctuating Rashba field is significantly different from that in the case of constant Rashba coupling[8].

[1] M. I. Dyakonov, V. I. Perel, ZhETF Pis. Red. **13**, 657 (1971).
[2] J. E. Hirsch, Phys. Rev. Lett. **83**, 1834 (1999).
[3] G. Vignale, J. Supercond. Nov. Magn. **23**, 3 (2010).
[4] M. M. Glazov, E. Ya. Sherman, V. K. Dugaev, Physica E **42**, 2157 (2010).
[5] V. K. Dugaev, M. Inglot, E. Ya. Sherman, J. Barnaś, Phys. Rev. B **82**, 121310(R) (2010).
[6] A. Dyrdał, J. Barnaś, Acta Phys. Pol. A **122**, 1016 (2012).
[7] A. Dyrdał, J. Barnaś, Phys. Rev. B **86**, 161410(R) (2012).
[8] A. Dyrdał, V. K. Dugaev, J. Barnaś, Phys. Rev. B **80**, 155444 (2009)