Spatial fluctuations of the Rashba field and their influence on electron and spin transport

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Spin-orbit driven phenomena belong to one of the most important areas of spin electronics - the so-called spin-orbitronics. The theoretical and experimental works within the spin-orbitronics are focused from one side on finding new features of electron and spin phenomena induced by spin-orbit fields, and from the second side on finding new materials (where spin-orbit coupling is strong enough) that might be easily used in the new generation of spintronics devices or matched with conventional electronics[1].

Spin-orbit coupling is a kind of a hallmark of the specific material or hybrid structure and symmetries which it possesses. Importantly, in a general case, spin-orbit coupling contains not only regular (spatially uniform or periodic) but also random component[2,3]. Local imperfections of the system, such as a random distribution of donors or impurities, may lead to local enhancement/suppression of the regular spin-orbit coupling. In consequence, charge carriers in the system propagate in an effective spatially fluctuating spin-orbit field. Such fluctuations of spin-orbit field strongly modify transport properties of the system and can induce a variety of experimentally observable effects.

During this presentation, we would like to focus on selected consequences of random Rashba field on transport properties in semiconductor heterostructures and graphene-like materials. We will show, among other things, that the spin Hall effect is robust to scattering on impurities in the presence of spatially fluctuating Rashba field[4-6]. We will also show that random Rashba field leads to a strongly nonlinear dependence of the anomalous Hall conductivity on magnetization[7]. Finally, we will discuss the influence of Rashba fluctuations on the charge and spin conductivity. In this case, an important role plays the transport relaxation time for charge and spin currents. It may be substantially different from times describing the electron momentum and spin relaxation and leads to a nontrivial temperature dependence of the conductivity[8]. Finally, we will also mention the role of random Rashba coupling in magnetoresistance responses.

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