Thermoelectricity and thermospin induced by the temperature gradient in ballistic graphene

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Both electric and spin currents, as well as the spin polarization of electrons can be induced by temperature gradient. The physics of these phenomena is spin caloritronics. The properties of nanosized objects are especially interesting at the sizes where the classical definition of temperature loses sense [1]. Usually, CVD graphene has a large number of carbon atoms and is not perfect since it includes many impurities and defects. But when we go to smaller sizes, the transport changes from diffusive to ballistic [2].

In this work we consider the ballistic electron and spin transport induced by the temperature gradient. For this purpose we assume two reservoirs with different temperatures separated by the region smaller then electron mean free path ℓ. When the graphene sheet is placed on a heavy atom substrate, the Rashba spin-orbit interaction occurs. In this case the linear spectrum of electrons near the Dirac point is parabolic and spin dependent.

We consider a graphene ribbon which on both ends is attached to electron reservoirs with different temperatures. The graphene ribbon is assumed to be on a substrate, that leads to a spin-orbit coupling of Rashba type. We calculated thermoelectrically induced charge transport in the ballistic regime. Apart from this, we calculated thermally induced spin currents and spin polarization in graphene. The spin currents have two components: one is parallel to the temperature gradient and the other perpendicular to the gradient. The latter one corresponds to the spin Nernst effect. We demonstrate how the charge and spin currents, spin pollarization and the heat current depend on the chemical potential μ, Rashba SO coupling parameter α and temperature difference ΔT.

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