Spin-polarized current induced by three terminal geometry

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Recently there has been a considerable interest in "spin-tronic" devices, where the spin degree of freedom of the electron plays a crucial role. One of the most well-known spin-tronic devices is the spin-transistor[1], where the sample with spin-orbit interaction is attached to two ferromagnetic leads. However, due to the existence of the high potential barrier between the ferromagnetic lead and the sample, most of the electrons can not enter into the sample region. Different methods are required to realize a spin-polarized current without using ferromagnetic contacts.

In this paper, we investigate numerically the spin polarization of the current in the presence of spin-orbit interaction with three terminal geometry[2]. We consider a two dimensional (2D) sample connected to three electron reservoirs by ideal leads (Fig.1). The sample region contains a spin-orbit interaction described by the Ando Hamiltonian[3]. We define the spin polarization of the current by that of the conductance because the current is proportional to the conductance in the inset of Fig.1.

$$\lambda = \frac{\sum_{\sigma''} G_{\uparrow,\sigma''} - G_{\downarrow,\sigma''}}{\sum_{\sigma,\sigma'} G_{\sigma,\sigma'}} \tag{1}$$

where $G_{\sigma,\sigma'}$ is the conductance from spin σ' to σ. Spin dependent conductance is defined by Landauer formula[4] as

$$G_{\sigma,\sigma'} = G_0 \sum_{i,j} |t_{i\sigma,j\sigma'}|^2, \quad G_0 \equiv \frac{e^2}{h} \tag{2}$$

where $t_{i\sigma,j\sigma'}$ is the transmission coefficient from the channel (j,σ') to (i,σ).

We extend the Green functional method[5] to the case of three terminal geometry. Fig.2 shows the energy dependence of the spin polarization. We obtained high spin polarization at the energy just before the number of channels increases.

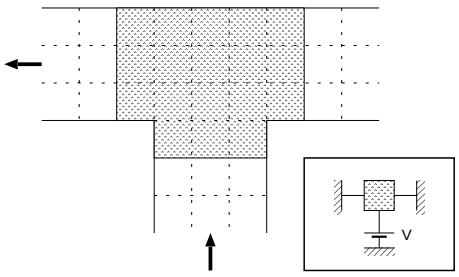

Figure 1: Three terminal geometry

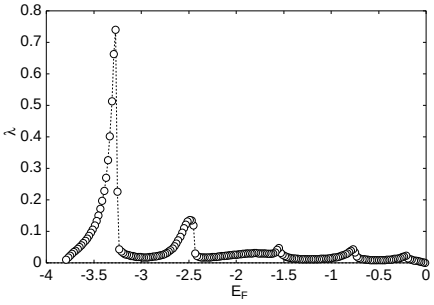

Figure 2: Energy dependence of the spin polarization

References

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