Notes on PRB.67.092408

1 spin field effect transistor

A type of quantum field effect transistor that operates purely on the flow of spin current in the absence of charge current. The rotating field induces a time-independent dc spin current, and at the same time generates no charge cur- rent. The physical principle of our SFET is due to a spin flip mecha- nism provided by the field.

2 Hamiltonian

A rotating magnetic field is

$$B_x = B_0 \sin\theta \, \cos(\omega t) \tag{1}$$

$$B_y = B_0 \sin\theta \, \sin(\omega t) \tag{2}$$

$$B_z = B_0 \cos\theta . \tag{3}$$

The Hamiltonian of system is

$$\begin{aligned} H = & \sum_{k,\sigma,\alpha=L,R} \epsilon_k C^{+}_{k\alpha\sigma} C_{k\alpha\sigma} + \sum_{\sigma} \left[\epsilon + \sigma B_0 \cos\theta\right] d^{+}_{\sigma} d_{\sigma} \\ & + H'(t) + \sum_{k,\sigma,\alpha=L,R} \left[T_{k\alpha} C^{+}_{k\alpha\sigma} d_{\sigma} + \text{c.c.}\right] \end{aligned} \tag{4}$$

We assume that there is only one orbit in the scattering region.

$$\epsilon_{Lk} = \epsilon_{Rk} = \epsilon_k .$$

A counterclock-wise rotating field allows a spin-down electron to absorb a photon and flip to spin-up, and it does not allow a spin-up electron to absorb a photon and flip to spin-down.

The scattering region is characterized by an energy level$\epsilon = \epsilon_0 - qV_g$, controlled by the gate voltage V_g.

We solve the transport properties (charge and spin currents) of the model in both adiabatic and nonadiabatic regimes using the stan- dard Keldysh nonequilibrium Green's function technique.

3 Adiabatic regime(ω is small)

References

[1] Y, K, Kato. Observation of the Spin Hall Effect in Semiconductors[J]. Science, 2004.