Calculation of conductance in a system with a single Weyl node

Oguz Turker

April 10, 2018

Abstract

1 Commutation rules

The fermionic operators that creates(anhilliates) particles in a given band can be written in terms of slave operators as;

$$a_{k_\pm} = f_{k_\pm} \tau^x_k. \tag{1}$$

Operators a and f obey usual fermionic anti-commutation relations which are given as,

$$\{f_k, f^\dagger_{k+q}\} = \delta_{0,q}, \tag{2}$$

and,

$$\{a_k, a^\dagger_{k+q}\} = \delta_{0,q}, \tag{3}$$

if we substitute eq 2 to eq 3 we have

$$\tau_k f_{k+q} f^\dagger_k \tau_{k+q} - f_{k+q} \tau_{k+q} \tau_k f^\dagger_k = -\delta_{0,q} + \tau_k \delta_{0,q} \tau_{k+q} \tag{4}$$

2 Current operator

Since we are working in momentum space we will write the current operator and the continuity equation in momentum space. The Fourier transform of the current operator is;

$$J(r) = \frac{1}{V} \int dq J(q) e^{iqr} \tag{5}$$

and the Fourier transform of the density operator is

$$\rho(r) = \frac{1}{V} \sum_q dq \rho(q) e^{iqr}, \tag{6}$$

where

$$\rho(q) = \sum_k a_k^\dagger a_{k+q}. \tag{7}$$

We can find the continuity equation for a given q as

$$\dot{\rho}(q) = -iqJ(q) \tag{8}$$

if we use Heisenberg's equation of motion, we have

$$[H, \rho_q](t) = qJ_q. \tag{9}$$

Now let us write eq 7 in terms of slave operators

$$\rho_q = \sum_k \tau_k f_k^\dagger f_{k+q} \tau_{k+q}. \tag{10}$$

Our hypothesis is current is carried by only f particle. We want to show that the current operator consists of only f and $f^\dagger$ operators. If we use eq2 we find that

$$\rho_0 = \sum_k f_k^\dagger f_k \tag{11}$$

but, ρ_0 does not contribute to the current which is clearly seen by eq8. The $\rho_{q\neq 0}$ cannot be written only in terms of f operators. For now it seems to be this slave spin approach does not make the problem easier, nor the J can be written in terms of solely f's.