Finite size scaling of the time reversal Weyl semimetal model

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Project nature and purpose

Recently, Weyl semimetal is a hot research topic in Physics. The Weyl semimetal is a newly proposed quantum state of the kind that breaks time reversal or inversion symmetry. Some interesting theoretical result have been proposed, more importantly, there are recent experimental confirmations of this kind of material, which spark the gold rush of Weyl semimetal[1,2,3]

1, Xu, S.-Y. *et al. Nature Phys.* http://dx.doi.org/10.1038/ nphys3437 (2015).

2, Lv, B. Q. *et al. Nature Phys.* http://dx.doi.org/10.1038/ nphys3426 (2015).

3, Lv, B. Q. *et al. Phys. Rev. X* **5,** 031013 (2015).

- As shown in the Figure 1, Weyl fermions, would exhibit a new kind of surface state: an open Fermi arc, which would connect two Weyl nodes and then continue on the opposite surface of the material.

Now, The future of the field is bright. Ultimately, we would like to find a unique transport signature of Weyl fermions.

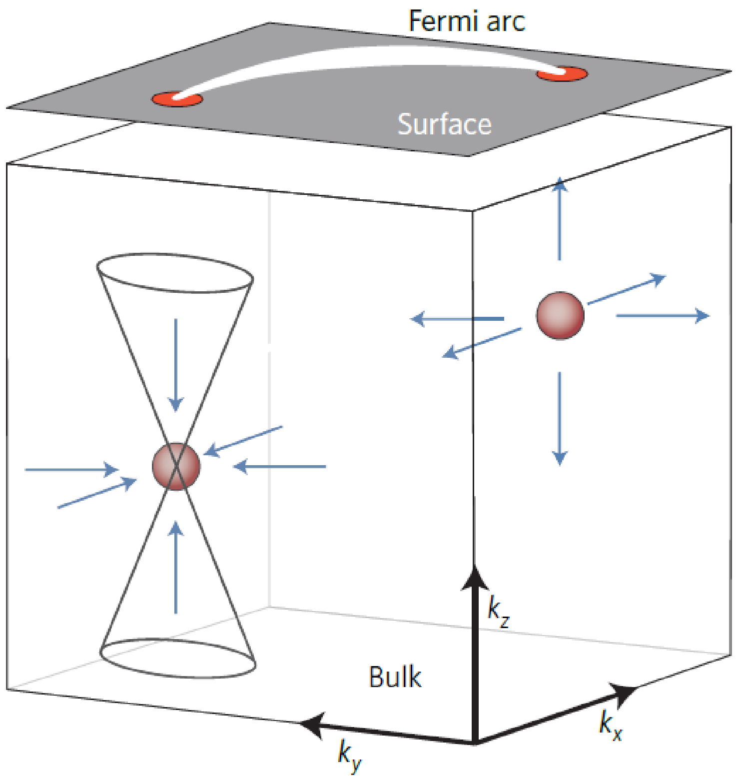


Figure 1 | Weyl semimetals in momentum space. Two Weyl nodes (red) act as monopoles, which have linear band dispersions (black) and are connected by a Dirac string (yellow). The top plane (grey) shows the two-dimensional projection, which has a Fermi arc (yellow) that connects the nodes and can be observed in photoemission experiments.

- Our model start from the time reversal Weyl semimetal Hamiltonian

$$H = 2d[2 - \cos k_x - \cos k_y] s_0 \otimes \tau_0 + [m + t\cos k_z + 2b(2 - \cos k_x - \cos k_y)] s_0 \otimes \tau_3$$
$$+ a \sin k_x s_3 \otimes \tau_1 + a \sin k_y s_0 \otimes \tau_2 + \beta s_2 \otimes \tau_2 + \alpha \sin k_y s_2 \otimes \tau_1$$

This is a time reversal system constructed by ourselves, which one can check by TR operator. This model can be better used in the experimental realization than the inversion breaking version.

- Our purpose is to study the disorder effect on the transport properties of the Weyl semimetal.
- As shown in the figure, disorder is

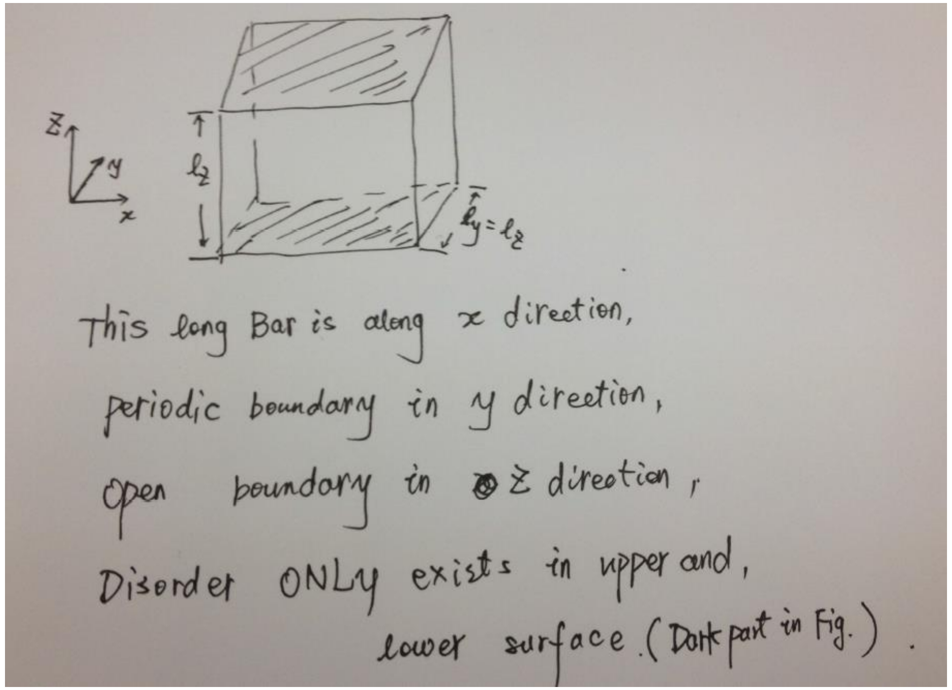
on the surface of the configuration.

By study the one-parameter scaling

of localization length and conductance

 in disordered systems, one can find the

Metal-insulator transition.



Objectives and Significance :

- By the finite size scaling theory mention above, we want to locate the

Metal-Insulator transition of this time reversal Weyl semimetal model, and get more accurate effect of disorder on the transport properties and surface states.

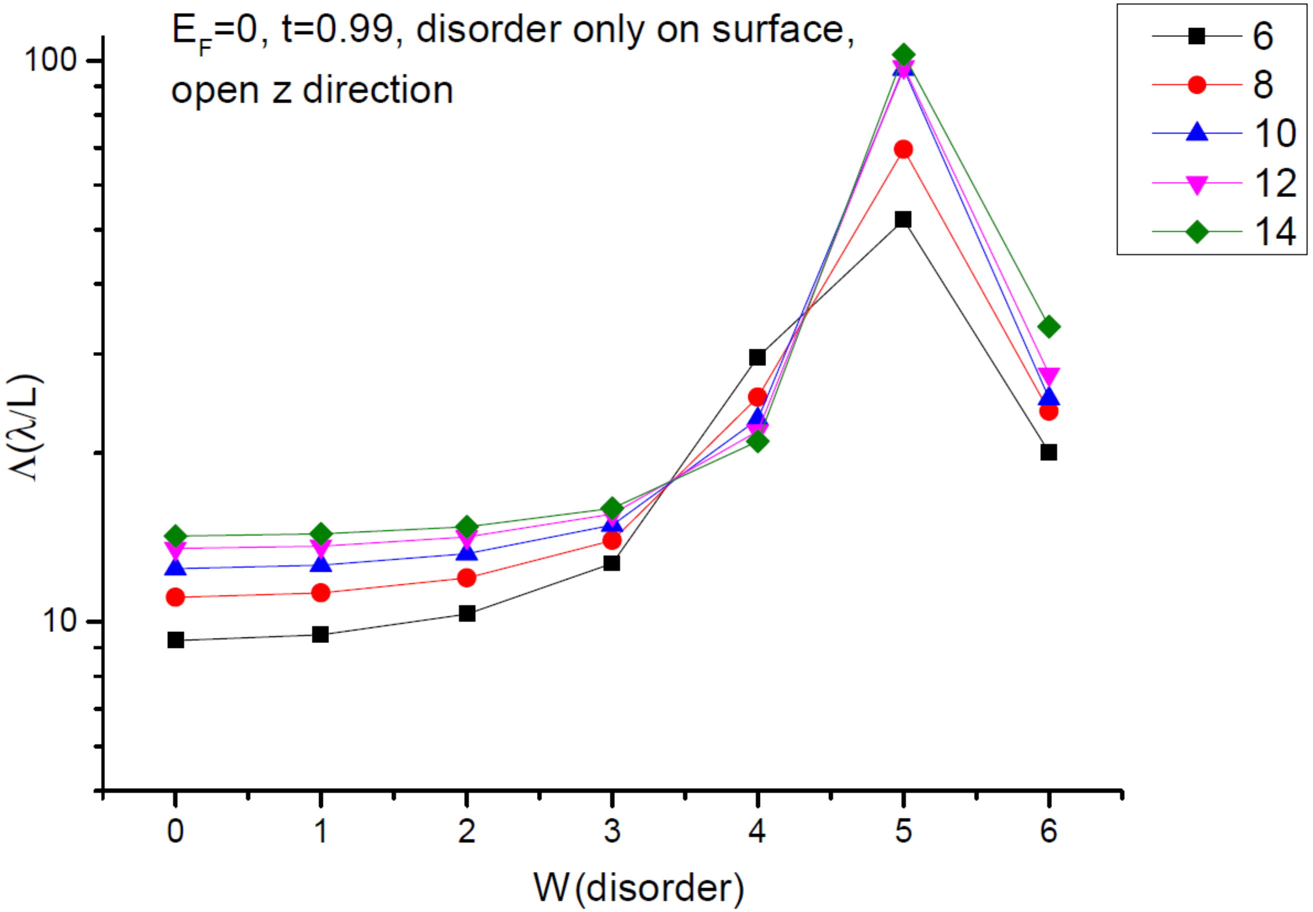
We may locate the critical transition point clearly, which can give us better understanding of the properties of the Weyl semimetal and also instruction for experiments.

Computing requirements

- As we know, for the disordered system, we use mathematical model to put the disorder in the system. We have to do the statistical average on disorder configuration, that is we have to calculate as many times(e.g 100000times) as possible to make the result converge and the errors small, this process is very time consuming.

- Second, the result accuracy is affected by the size of the system, so we hope the system the bigger, the better. But as the size increases, the computation becomes more difficult since it is proportional to N$= L^3$, which means as we increases size 4 times, N will increase 64 times.

- This figure is our primary result as expected, which takes at least two week to calculate.



- In summary, this project is interesting and meaningful, but it is calculation consuming. So we are here to look for your help.

Thank you very much