Violation of Ohm's law in Weyl metal $Bi_{1-x}Sb_x$

Shin, D.W., Kim, J.H. (POSTECH, Physics)

Introduction

Weyl metal is 3d analogue of graphene which has Weyl cone in reciprocal lattice when either time reversal symmetry or inversion symmetry is broken. Owing to a topological structure of the chiral anomaly in the Weyl metal, negative longitudinal magneto resistance (NLMR) appears in transport measurement. Besides the NLMR, we observed Ohm's law is broken in $Bi_{1-x}Sb_x$ (x=0.04) and analyze the phenomenon by systematical experiment and semi-classical theory.

Experimental

We carried out transport measurement in $Bi_{1-x}Sb_x$ (x=0.04). At the first, we reproduce NLMR with applying magnetic field parallel to electric field [1]. And we measured IV curve with 9 T parallel to electric field. In the configuration, we observed non-linearity in the IV curve and we can observe that the non-linearity is reduced with decreasing magnetic field and increasing temperature. For investigating the non-linearity, we measured Hall voltage and Shubnikov-de Hass oscillation noting that our samples are in the quasi-classical limit.

Results and Discussion

Non-linearity in IV curve is observed in Weyl metal which is enhanced by high magnetic field and low temperature as **Fig.1**. We analyze the non-Ohmic behavior using the Boltzmann transport equation including both intra-node scattering and inter-node scattering, which is coincident with experimental results. Because the theoretical analysis is based on the classical theory, we performed high-magnetic field experiment to observe Sdh oscillation. The high-magnetic field experiment shows small oscillation frequency which is consistent with small carrier density of the sample and is in good agreement with those obtained from our Hall analysis noting that our sample in in semi-classical region.

Conclusions

We have observed violation of Ohm's law in $Bi_{1-x}Sb_x$ (x=0.04) for E // B in the Weyl metal state. The non-ohmic response in the I-V curve, originating from the non-trivial topological structure of a Weyl metal together with charge pumping, is a characteristic feature of the topological Weyl metal state. The presence of ohmic and non-ohmic features within a single material provides an important perspective for novel device applications beyond conventional ohmic devices.

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References

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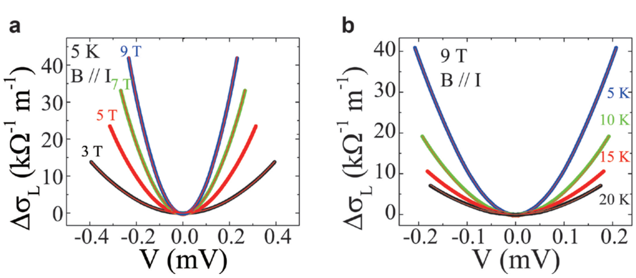

Fig.1 The field-temperature dependence of nonlinear conductance.