Unusual interlayer quantum transport caused by the zeroth Landau level in $YbMnBi_2$

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Introduction

Relativistic fermions in topological quantum materials are characterized by linear energy-momentum dispersion near band crossing points. Under magnetic fields, relativistic fermions acquire a Berry phase of π in cyclotron motion, leading to a zeroth Landau level (LL) at the crossing point. Here we report the unusual interlayer quantum transport behavior resulting from the zeroth LL mode in the topological semimetal $YbMnBi_2$ [1]. The interlayer magnetotransport of this material is found to exhibit surprising angular dependences, which can be well fitted to a model which considers the interlayer quantum tunneling transport of the zeroth LL's Weyl fermions [2].

Experimental

We have synthesized $YbMnBi_2$ single crystals using a flux method, and carried out systematic angular-dependent magneto-transport studies by using a 9-T PPMS and a 31T (Cell 9) resistive magnet at NHMFL.

Results and Discussion

With rotating the magnetic field orientation, we observed low-field (B<1T) $\sin^2\theta$ dependence for the interlayer magnetoresistance, which is naturally expected as a result of Lorentz effect. In contrast, a surprisingly sharp peak develops at θ=90° at high fields (Fig. 1a). Similar anomalies are also probed in interlayer Hall effect. At lower fields, the transverse Hall conductivity obtained through resistivity-conductivity tensor conversion displays a commonly seen sinθ-like dependence. However, a local minimum at θ=90° gradually develops with raising fields (Fig. 1b). Those unusual evolutions of both interlayer longitudinal and transverse electron transport with magnetic field orientation cannot be described by the classical model, but can be understood by considering the zeroth LL quantum tunneling (see fittings in Figs. 1a and 1b) [2], which takes place in $YbMnBi_2$ due to the pinning of the zeroth LLs of Weyl cones at Fermi level and become stronger with increasing magnetic field.

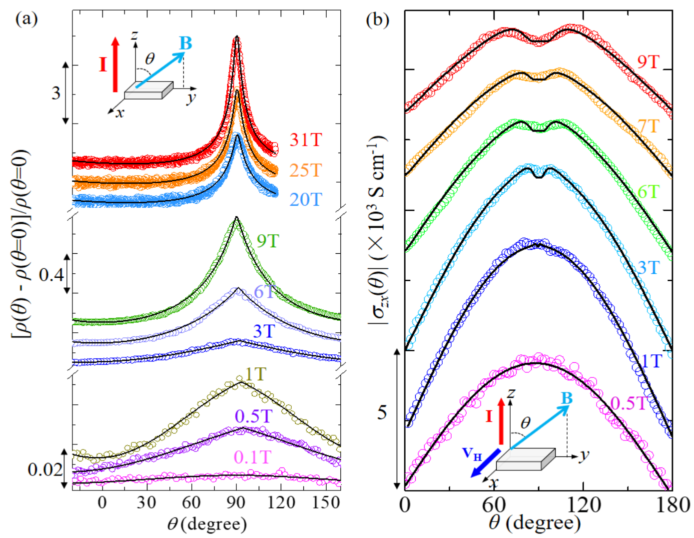

Fig. 1 (a) Normalized angular-dependent interlayer longitudinal magnetoresistance. Inset: the measurement setup. (b) Angular-dependent transverse conductivity σ_{zx}, obtained by tensor conversion. Inset: the setup for measuring one tensor element ρ_{xz}. The solid lines show the fitting to the model considering the interlayer quantum tunneling of the zeroth LL's Weyl fermions [2]

Conclusions

In this work, we have studied the interlayer magnetotransport of $YbMnBi_2$. The unusual angular-dependence of longitudinal and transverse electron transport can be quantitatively interpreted by considering the interlayer tunneling of Weyl fermions at the zeroth LLs. Our finding highlights the unusual role of the zeroth LLs in transport, which is important to further understand the novel Dirac/Weyl fermion physics.

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References

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[2] Liu, J.Y., et al., Nature Commun. **8**, 646 (2017).