Possible Broken Valley-Degeneracy in Anisotropic Dirac Fermions of $SrMnBi_2$

Y.J. Jo (Kyungpook U., Physics); E.S. Choi (NHMFL); W. Kang (Ewha Womans U., Physics); J.S. Kim (POSTECH, Physics)

Introduction

Valley degeneracy in two dimensional electron systems is of significant interest for potential applications of multi-channel devices with valley polarization properties. Recent study on angle-dependence magnetoresistance in bismuth nicely demonstrates that contribution of the conductivity from each valley can be modulated by controlling the direction of an applied magnetic field. Our recent work on $SrMnBi_2$ single crystals show that the Bi square net of $SrMnBi_2$ can also host Dirac fermions with a strong anisotropy in momentum-dependent Fermi velocities. The existence of highly anisotropic Dirac cone has been demonstrated by first principle calculations, angle-resolved photoemission and the Shubnikov-de Haas (SdH) oscillations.

Experimental

In order to perform the detailed electronic properties in such an anisotropic Dirac state, we carried out anglular dependent magnetoresistance oscillations (AMROs) of $SrMnBi_2$ under a field up to 35 T. The interlayer transport property, i.e. c-axis resistivity ρ_c, was measured using a conventional four-contact method under tilted magnetic fields. The definitions of the polar (θ) and azimuthal (ϕ) angles of the magnetic field are given in Fig. 1(a).

Results and Discussion

The ρ_c at tilted magnetic fields exhibits clear AMRO behaviors in Fig. 1(a). The azimuthal angle ϕ is fixed at $\phi=30^o$. The AMRO near H//c corresponds to the SdH effect whereas AMRO near H//ab arises from the geometrical effect of the quasi-2D FS whose positions are not sensitive to the field strength. At special angles when the whole FS has only one extremal cross sectional area, the electron velocity component along the interlayer direction averaged over the orbits disappears, which gives interlayer resistance peaks i.e. Yamaji oscillations.[1] The large peak at $\theta=90^o$, so-called coherent peak generally arises from small closed orbits of the sides of corrugated 2D FS.[2] Fig. 1(b) shows the ϕ-dependence of the coherent peak at high magnetic fields up to 30 T at 2 K. The four-fold symmetry in $\rho_c(\phi)$ clearly present at low magnetic fields, is gradually destroyed at higher magnetic fields.

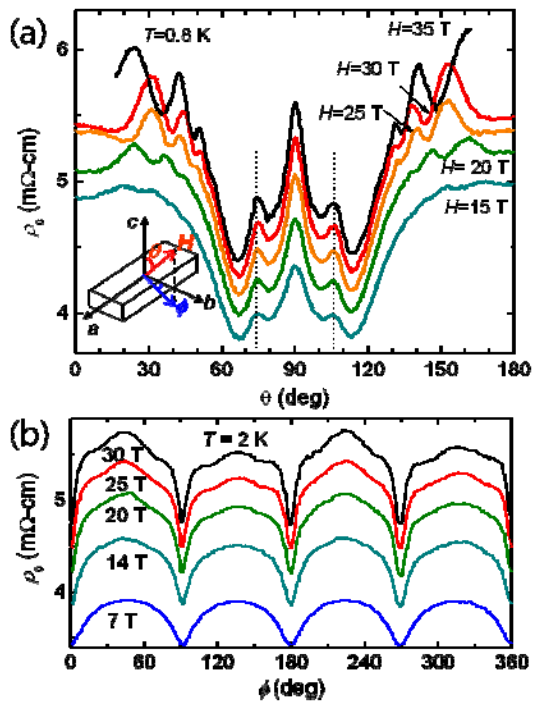

Fig. 1 The polar angle (θ) dependence (a) and azimuthal (ϕ) angle dependence (b) of the c-axis resistivity in various magnetic fields. The inset shows the definition of polar (θ) and azimuthal (ϕ)

Conclusions

We report that the interlayer conduction of $SrMnBi_2$ can be valley-polarized at a tilted magnetic field. The c-axis resistivity of $SrMnBi_2$ show coherent interlayer conduction evidenced by the coherent peak and Yamaji oscillations in angle-dependent magnetoresistance oscillations. Under magnetic field rotating in the plane, we found strong variation of the coherent peak with four-fold symmetry. This is attributed to field-induced change of the contribution from each valley in the interlayer conduction, due to the highly anisotropic FS. We found loss of four-fold symmetry suggesting possible broken valley degeneracy at high magnetic field. These results suggest that the valley control using magnetic field provides effective way to modulate the interlayer conduction in quasi-2D Dirac system, $SrMnBi_2$.

Acknowledgements

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References

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