Evidence for Massive Bulk Dirac Fermions in $Pb_{1-x}Sn_xSe$ from Thermopower Experiments at High Fields

N.P. Ong, T. Liang, J. Xiong, M.A. Hirschberger (Princeton U., Physics)

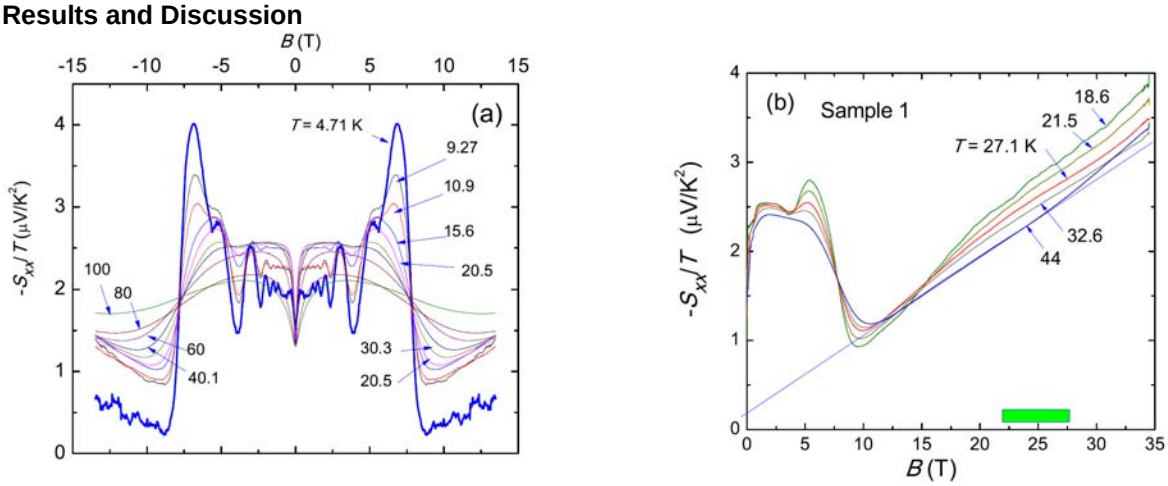
Introduction

Topological surface states protected by mirror symmetry are of interest for spintronic applications. Such states were predicted to exist in the rocksalt IV–VI semiconductor $Pb_{1-x}Sn_xSe$. An underlying assumption in the theory is that the surface states arise from bulk states describable as massive Dirac states, but this assumption is untested. Massive Dirac fermions and Schrödinger electrons differ by a distinctive feature in their Landau Level (LL) spectrum that is robust against small perturbations. Generally, in the spinful massive Dirac Hamiltonian, the lowest LL is predicted to have a spin degeneracy of one, whereas all higher LLs are doubly spin-degenerate. By contrast, all LLs are doubly degenerate for the Schrödinger case. Here we show that the thermoelectric response of the bulk states at high fields displays features specific to the Dirac spectrum.

Experimental

Thermopower signal was measured up to 35T at cell 12, 35T magnet at the National High Magnetic Field Laboratory using standard DC measurement technique.

Results and Discussion



As shown in Fig. a, oscillations in S_{xx} grow rapidly below 60 K. The most prominent feature in S_{xx} is the large step-decrease at the field B_1 = 7.7 T at which chemical potential drops to the N = 0 LL. From the slope of the index plot of quantum oscillations, we infer a Fermi wavevector k_F = 0.0134 Å^{-1} and a carrier density (per valley) $n_e = 8.2\times10^{16}$ cm^{-3}. Together, B_1 and n_e suffice to determine the spin degeneracy of the N = 0 LL to be nondegenerate [1]. The B-linear dependence of the N=0 LL smoothly extends through the region 22–28 T where the transition (0,-) → (0, +) should have appeared if the system were Schrödinger electrons (The interval 22–28 T is indicated by the horizontal green bar). Thus, the thermopower signal at high fields shown in Fig. b confirms the system to be Dirac fermions.

Conclusions

We reported Nernst and thermopower evidence that the bulk states in the gap-inverted phase of $Pb_{1-x}Sn_xSe$ are Dirac fermions rather than Schrödinger electrons.

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References

[1] Tian Liang, *et al*., Nature Communications **4**, doi:10.1038/ncomms3696 (2013)