Quantum Transport of Dirac Fermion Systems Under Pressure

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Introduction

Dirac Fermion compounds are a recent topic of interest in condensed matter physics as observed in the examples of graphene and topological insulators such as Bi_2Te_3. Similarly, both $CaMnBi_2$ and $SrMnBi_2$ contain 2D square nets of Bi which create linear energy dispersions resulting in very low effective masses and large mobilities. Here we report on the effect of high pressure on the quantum oscillations found in these pnictide materials.

Experimental

Six contacts were added to single crystals of $SrMnBi_2$ and $CaMnBi_2$ that were grown using a self-flux method to allow for longitudinal (R_{xx}) and transverse (R_{xy}) transport measurements. The samples were mounted on the platform of a MP35N piston cylinder cell and enclosed in an environment of oil. Magnetoresistance measurements were performed in Cell 12 at the NHMFL-Tallahassee up to 35 T and with temperatures down to 350 mK.

Results and Discussion

Transport measurements were taken with a lock-in or resistance bridge as the magnetic field was swept, as shown in **Figure 1**a. For $SrMnBi_2$, a single oscillation frequency was apparent at F ~ 148 T with an applied pressure of ~ 4.1 kbar. Using the Lifshitz-Kosevich damping parameter for temperature an effective mass of $0.17m_e$ is found. The frequency is higher while the mass is lower than what was found at ambient pressure. [1,2]

A systematic study of the pressure dependence of the frequencies shows that pressure initially enhances the size of the orbit for both $SrMnBi_2$ and $CaMnBi_2$ from the values at ambient pressure [1,3]. Beyond ~ 4 kbar, the frequency of $CaMnBi_2$ begins to decrease. Also, as pressure increases the mobility of the carriers begins to decrease with a value of ~ 550 cm^2/Vs at 14 kbar, a factor of almost four smaller than at ambient pressure.

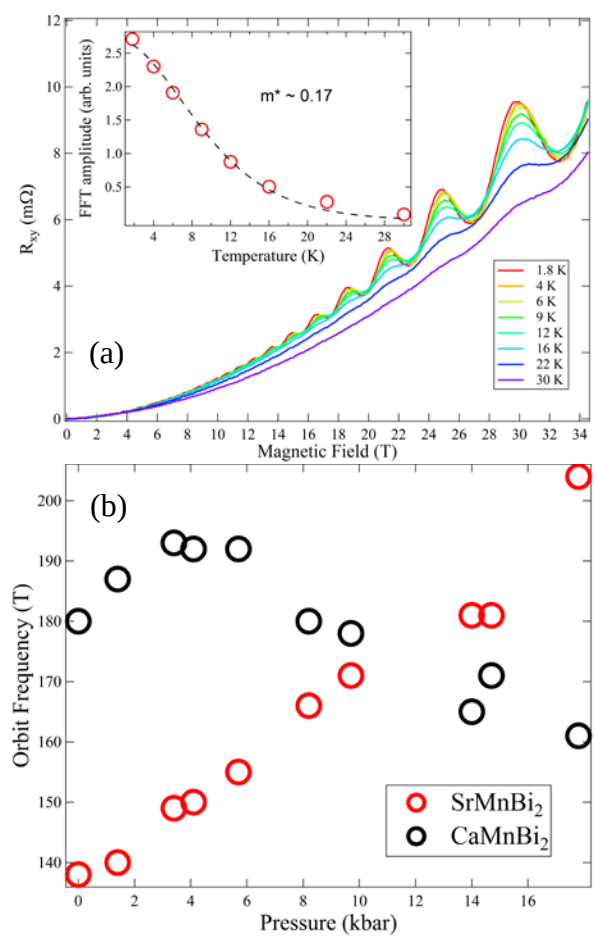

Figure 1. (a) Temperature dependence of tranverse magnetoresistance in $SrMnBi_2$ at P ~ 4.1 kbar. Inset: Effective mass fit for data in (a). (b) Pressure dependence of the oscillation frequency for the listed layered pnictides compounds.

Conclusions

With the application of moderate pressures up to ~ 18 kbar we find the orbit sizes of $CaMnBi_2$ and $SrMnBi_2$ shift in opposite directions with the same frequency near P ~ 11 kbar. Further work in underway to determine the effect of pressure on other transport properties of these compounds.

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References

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