Clarifying the Number of Shubnikov-De Haas Frequencies in BiTeCl

Martin, C. (Ramapo College); Suslov, A.V. (NHMFL); Buvaev, S. (UF, Physics); Hebard, A. F. (UF, Physics); Bugnon, P. (EPFL); Berger, H. (EPFL); Magrez, A. (EPFL); Tanner, D.B. (UF, Physics)

Introduction

BiTeCl may represent the first example of an inversion asymmetric topological insulator, and with a large Rashba spin-splitting of its bulk electronic bands. In a recent work, we reported (based on a previous experiment at the NHMFL) the observation of two distinct Shubnikov-de Haas (SdH) oscillations (a lower $F_1 \approx 70$ T and a larger $F_2 \approx 160$ T), with unusual temperature dependence. The frequencies were assigned to the bulk Rashba spin-split conduction band, when the Fermi level is situated above the crossing (Dirac) point. In order to address their temperature dependence and concerns related to the proximity of F_2 to the second harmonic of F_1, we performed a new experiment, on the same sample (freshly cleaved), aiming to disentangle the two frequencies.

Experimental

For this experiment we used the same single crystal of BiTeCl as in a previous run, with dimensions of 3 × 2 × 0.1 mm^3. The sample was freshly cleaved and six electrical contacts were made on one of its surfaces, using gold wire and silver paste. Measurements of electrical resistance were performed on different contacts configurations, in magnetic field up to 31 Tesla and temperatures as low as 0.5 K, using a resistive magnet facility (Cell 9) at the NHMFL.

Results and Discussion

We successfully found two configurations such that the low frequency (F_1) would dominate the SdH signal (left figure) in one of them and the higher frequency (F_2) would be dominant in the other (right figure). This not only confirmed the distinct nature of the two oscillations, but also allowed us to separately study their temperature and angular dependencies. While the carrier effective masses were found to be similar, as we previously reported, the angle dependence of the two oscillations was very different, suggesting different dimensionalities of the Fermi surface.

Conclusions

In conclusion, we successfully resolved two Shubnikov-de Haas oscillations in single crystals of BiTeCl, which gave us insight into the electronic structure of this compound and allowed for a reliable estimation of the magnitude of the bulk Rashba spin-splitting in BiTeCl.

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References

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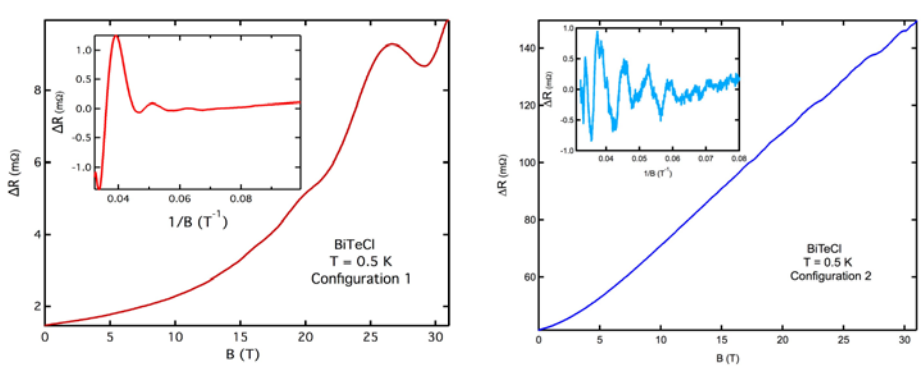

Fig.1 Shubnikov-de Haas oscillations in BiTeCl, showing two distinct frequencies: $F_1 \approx 70$ T (right) and $F_2 \approx 160$ T (right)