Transport Properties of Weyl Semimetal Mn_3Sn

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May 17, 2022

Abstract

The antiferromagnetic Weyl semimetal Mn_3Sn has recently been of great interest because of the exotic transport behaviours it exhibits at room temperature such as Planar Hall Effect (PHE), large Anomolous Hall Effect (AHE) and negative magnetoresistance. These exotic behaviours, rarely found in antiferromagnets has potential to be utilized in future spintronics devices.Mn_3Sn compounds need to be stabilized in excess of Mn, which means that the actual composition is $Mn_{3+\delta}Sn$ ($\delta = 0.05 - 0.3$). Reports of the different exotic effects as well as other properties are therefore often attained from samples with varying Mn concentration. In this thesis we present extensive measurements of both electronic and magnetic transport properties of $Mn_{3.13}Sn$ for a wide temperature range with the goal to map all the transport properties of Mn_3Sn for a single compound.

All measurements are conducted at the Jülich Centre for Neutron Science (JCNS) using the Quantum Design Physical Property Measurement System (PPMS) and Magnetic Property Measurement System (MPMS). Three transition temperatures of $Mn_{3.13}Sn$ can be identified; $T_f = 45$ K, $T_t = 245$ K and $T_N = 45$ K. Below T_f we confirm a weakly ferromagnetic phase with magnetic lowest-energy direction [0001]. AC susceptibility measurements also reveal a slight glassiness in this phase consistent with previous reports. Furthermore, magnetoresistance (MR) measurements display competing Weak Localization and Anti-weak Localization effects below T_f.

Above T_t we observe PHE, AHE as well as negative MR. We identify a six-fold anisotropy confirming a triangular antiferromagnetic spin structure above T_t and observe the lowest-energy direction in the triangular configuration to be $[11\bar{2}0]$. This phase is also weakly ferromagnetic and we find the easy direction to be in $[11\bar{2}0]$ direction for low external magnetic field shifting to [0001] at high magnetic field. To further characterize the change in lowest-energy direction further studies are needed.