Coulomb Disorder in Cd_3As_2 Thin Films

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Efforts to move topological semimetals (TSMs) toward applications requires understanding of defects and disorder in thin film analogues. Coulomb disorder has important consequences for the properties of topological semimetals (TSMs) [1, 2]. In TSMs, Coulomb disorder is introduced through the presence of charged native defects which become screened contingent on the Fermi energy (E_F) or carrier density (n). The resulting disorder potential is characterized by an average magnitude eV_0 and correlation length ξ. In the limit of weak disorder, when $eV_0 < E_F$, nonsaturating linear magnetoresistance can emerge in many TSMs – generated from scattering from the disorder potential. In Cd_3As_2, we have demonstrated the link between this linear magnetoresistance and the disorder potential [3,4]. Here, we utilize a series of (001)-Cd_3As_2 bulk-like thin films (gapless bulk) to study the effects of Coulomb disorder on the electrical transport for a range of carrier densities. The ultralow carrier densities we obtain have two main effects on the Coulomb disorder: i) the magnitude of the disorder potential increases as screening is reduced and ii) the Fermi energy is reduced, becoming more comparable to eV_0. The combination of these effects serves to move Cd_3As_2 into a strong Coulomb disorder regime with decreasing carrier density ($E_F \sim eV_0$), as shown in Figure 1. The solid black line is calculated for Cd_3As_2 using Ref. 1 and circles are placed in line with sample carrier densities. As eV_0/E_F increases, we find a striking crossover in the magnetic field dependence of the resistivity from linear to quadratic. We connect this change in magnetoresistance to strong Coulomb disorder scattering [5,6].

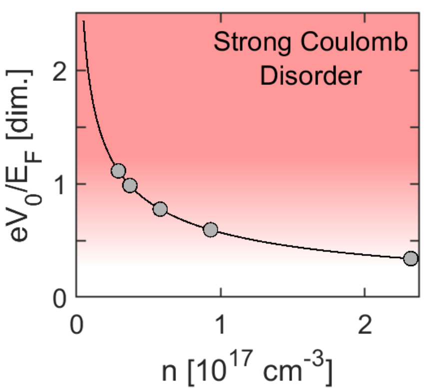

Figure 1: Ratio of the average disorder potential strength to the Fermi energy as a function of carrier density in Cd_3As_2. Points correspond to carrier densities for samples in the study. The black line is calculated from Ref. 1.

References:
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