**Magnetic Torque Anomaly in the Quantum Limit of Cd3As2**

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**Introduction**

Dirac and Weyl semimetals have excited physicists due to their unique electronic structure. In these materials, quasiparticles behave as massless Dirac or Weyl fermions, obeying a linear dispersion relation in three dimensions. Although both Weyl and Dirac semimetals exhibit linear dispersion relations, the Dirac node is actually composed of two degenerate, opposite-chirality Weyl nodes, which are protected from mixing by crystal symmetry. Breaking the crystal symmetry, therefore, leads to the mixing of the Weyl nodes and the opening of a gap. To observe the opening of such a gap, we attempted to measure the quantum limit magnetic torque anomaly that was previously observed in the Weyl semimetal NbAs on the Dirac semimetal Cd3As2. The torque anomaly stems from the pinning of the last Landau level at zero energy in a system in which the charge carriers are massless Weyl or Dirac fermions. This pinning leads to a paramagnetic response at low fields, which switches to Landau diamagnetism at the quantum limit, observed as a change in the sign of the magnetic torque [1]. When the system becomes gapped, however, the quasiparticles are no longer massless and Landau diamagnetism is displayed over the entire field range. As a result, there is no sign change in the magnetic torque.

 In the Dirac semimetal Cd3As2, the degenerate Weyl nodes are protected from mixing by the C4 rotational symmetry present about the c-axis. Applying a magnetic field along the c-axis breaks this symmetry, leading to the mixing of the Weyl nodes and the opening of a gap. Applying a magnetic field in the ab-plane, however, preserves the C4 symmetry, and the system remains gapless. Since the quantum limit torque anomaly is only present in gapless systems, measuring the angle-dependence of the magnetic torque in the vicinity of the quantum limit allows us to observe the transition between massive and massless quasiparticles in a Dirac semimetal.

**Experimental**

We measured the magnetic torque produced by single-crystals of Cd3As2 in pulsed fields up to 65T using piezoresistive silicon microcantilevers. We expected to observe a sign-change in the magnetic torque at the quantum limit when the field was in the ab-plane, but not along the c-axis. Unfortunately, however, the torque response from Cd3As2 is very small, rendering the low-field signal indistinguishable from the pulsed field noise. As a result, any change in the sign of the torque at the quantum limit could not be resolved. We attempted to improve the signal by using larger crystals, however, this decreased the resonant frequency of the cantilevers to the point where it could no longer be filtered out from the material response.

**Results and Discussion**

 We were unable to measure the opening of a magnetic field-induced gap in the Dirac semimetal Cd3As2 using magnetic torque. This was most likely due to the highly isotropic Fermi surface of Cd3As2 compared to other Weyl/Dirac semimetals such as NbAs. Torque is sensitive to the difference in magnetic susceptibilities along orthogonal crystal axes. Therefore, in a relatively isotropic system, a very small torque response is to be expected. In the case of Cd3As2, it was too small to be measured in pulsed fields. In the future, we plan to measure the magnetization of Cd3As2 directly, in order to observe the change from paramagnetism to diamagnetism. This is best accomplished using compensated, inductive, extraction magnetometry, a technique that has been perfected and used extensively at the NHMFL PFF in Los Alamos.

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**References**

 [1] Moll, P.J.W. et al., in preparation (arXiv:1507.06981, 2015)