HIGH MAGNETIC FIELD STUDIES OF LIGAND SITE SUBSTITUTED URu_2Si_2 (Si → P AND Ga)

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Materials that straddle the boundary between itinerant and local electron behavior are exemplary hosts for novel phenomena, including unconventional superconductivity, anomalous magnetism, non-Fermi liquid behavior, and exotic electronic phases. A well-known example is URu_2Si_2, which exhibits an unknown ordered state near T_0 = 17.5 K and unconventional superconductivity below T_c = 1.4 K. While intense interest has been directed towards this compound, there is no definitive understanding of its behaviors. Some insight comes from prior measurements in high magnetic fields, which uncovered the topology of its three dimensional Fermi surface, enhanced effective band masses, and a large *g*-factor anisotropy that is unexpected for itinerant quasiparticles [1]. While these observations placed constraints on theory, the puzzles presented by this compound still remain unsolved. To gain new insight, we have produced high quality single crystals of the previously inaccessible chemical substitution series $URu_2Si_{2-x}M_x$ (M = Ga and P) using a novel molten metal flux growth technique. In a simple picture, Ga and P substitution merely introduce holes and electrons, respectively. This provides a delicate tuning parameter that does not disrupt other important energy scales including the Coulomb, spin orbit, and crystal electric field interactions. We report a study of the magnetoresistance for these substitution series, where Shubnikov de Haas oscillations are observed for the first time in any URu_2Si_2 substitution series. These measurements uncover the hole/electron doping dependence of the Fermi surface, effective electronic masses, upper critical field, and g-factor anisotropy and thereby provide information about what factors are important for hidden order and superconductivity in URu_2Si_2.

[1] M. M. Altarawneh, N. Harrison, G. Li, L. Balicas, P. H. Tobash, F. Ronning, and E. D. Bauer, "Superconducting pairs with extreme uniaxial anisotropy," Physical Review Letters **108**, 066407 (2012).

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