Specific Heat as a Probe for Superconductivity in Pu-Based Materials

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Specific heat has proven to be a powerful probe for the study of electronic and magnetic properties of intermetallic materials [see e.g. 1]. Here we show that this technique is also a unique tool for the investigation of the superconducting properties in the recently discovered $PuCoGa_5$ [2] and $PuRhGa_5$ [3]. These compounds represent the first known Pu-based superconductors and display remarkably high critical parameters ($T_c \approx 18.5$ K and 8.7 K ; $H_{c2}(0) \sim 74$ T and 21 T, respectively), compared to other (U- and Ce-based) heavy fermion superconductors. Additionally, $PuCoGa_5$ and $PuRhGa_5$ appear to be close to a magnetic phase instability [4,5] and to display unconventional superconductivity [6,7]. Sharp lambda-type anomalies in the $C_p(T)$ curves indicate the transition to the superconducting state below Tc ≈ 18 K and 9 K, respectively. In both systems, the electronic specific heat below T_c follows a quadratic temperature dependence that indicates an axial state with line nodes in the superconducting gap structure. A Sommerfeld coefficient around 100 $mJmol^{-1}K^{-2}$ and between 80 and 150 $mJmol^{-1}K^{-2}$ is estimated for $PuCoGa_5$ and $PuRhGa_5$, respectively. Measurements of oriented single crystals in magnetic fields up to 9T applied along the main crystallographic directions reveal anisotropic behavior in both compounds. Superconductivity is found to be more fragile when the magnetic field is applied along the c-axis than when perpendicular to it. Also, anisotropy effects are significantly stronger in $PuRhGa_5$ than in $PuCoGa_5$. The results are discussed in relation with the isostructural Np-based materials that exhibit magnetic order.

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