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Bulk Superconductivity in $PuCoGa_5$ at 18.5 K[+]

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Elemental plutonium is a fascinating metal yet poorly understood. A significant aspect of its complexity is the ambivalent nature of Pu's 5f electrons, which frequently appear to be neither completely localized nor fully itinerant. This issue is emphasized in $PuCoGa_5$, the first Pu-based superconductor and with a T_c exceeding 18 K. Though conventional phonon-mediated pairing may be responsible for its superconductivity, this view must be reconciled with three observations: (1) above T_c, the static susceptibility of $PuCoGa_5$ is Curie-Weiss-like with an effective moment of 0.68 μ_B, close to that expected for Pu^{3+}; (2) its Sommerfeld specific heat coefficient of 77 mJ/moleK^2 indicates that electronic correlations cannot be ignored; and, (3) isostructural $UCoGa_5$ is a Pauli paramagnet with much smaller Sommerfeld coefficient and is not superconducting above 0.3 K. Rather than a conventional superconductor, $PuCoGa_5$ appears to be more nearly analogous to the isostructural heavy-fermion superconductor $CeCoIn_5$ in which antiferromagnetic spin fluctuations mediate Cooper pairing. Also as in $CeCoIn_5$, the T=0 orbital upper critical field of 74 T in $PuCoGa_5$ exceeds the Pauli limit by nearly a factor of two. In a scenario of magnetically mediated superconductivity, the almost order of magnitude higher T_c in $PuCoGa_5$ would be attributed to stronger 5f-ligand hybridization. Perhaps $PuCoGa_5$ bridges two classes of unconventional superconductors—the heavy-fermion systems and high-Tc cuprates.

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