Penetration depth, symmetry breaking, and gap nodes in superconducting PrOs$_4$Sb$_{12}$


The vortex-state field distribution in the filled-skutterudite heavy-fermion superconductor PrOs$_4$Sb$_{12}$, in which there is evidence for time-reversal-symmetry (TRS) breaking, has been studied using transverse-field muon spin relaxation (TF-$\mu$SR).

The superconducting-state TF-$\mu$SR relaxation rate $\sigma_s(T)$, a measure of the vortex-lattice field distribution width, is found to be nearly constant below $\sim T_c/2$. Our results suggest $\lambda(T) \approx \text{const.}$ at low temperatures, consistent with a nonzero gap for quasiparticle excitations. Surface penetration-depth measurements in zero static field yield $\lambda(T) - \lambda(0) \propto T^2$, which suggests point nodes in the gap. A similar discrepancy is found in the TRS-breaking superconductor Sr$_2$RuO$_4$, but not in a number of non-TRS-breaking superconductors, conventional and unconventional.

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