Abstract Submitted to the
IICAM Workshop on Correlated Thermoelectricity
25 - 30 September, 2005
Hvar, Croatia

Strongly correlated electron phenomena in Pr-based filled skutterudite compounds

M. Brian Maple
Department of Physics and Institute for Pure and Applied Physical Sciences
University of California, San Diego, La Jolla, CA 92093 USA

The filled skutterudite compounds MT_4X_{12} (M = alkali metal, alkaline earth, lanthanide, actinide; T = Fe, Ru, Os; X = P, As, Sb) display a variety of strongly correlated electron phenomena including superconductivity, magnetic order, quadrupolar order, valence fluctuations, heavy fermion behavior, non-Fermi liquid behavior, and metal-insulator transitions. In this talk, we focus on the Pr-based filled skutterudites (i.e., M = Pr) and describe recent experiments on the systems $PrOs_4Sb_{12}$, $Pr(Os_{1-x}Ru_x)_4Sb_{12}$ and $PrOs_4As_{12}$. The heavy fermion compound $PrOs_4Sb_{12}$ exhibits unconventional strong coupling superconductivity below $T_c = 1.85$ K that breaks time reversal symmetry and apparently consists of several distinct superconducting phases, some of which may have point nodes in the energy gap. In contrast, $PrRu_4Sb_{12}$, which has a $T_c \approx 1$ K, displays conventional isotropic BCS superconductivity. In the $Pr(Os_{1-x}Ru_x)_4Sb_{12}$ system, increasing the Ru concentration x results in a monotonic increase of the crystalline electric field splitting between the singlet ground state and triplet first excited state of the Pr^{3+} ions from ~ 7 K at x = 0 to ~ 70 K at x = 1, a minimum in the T_c vs x curve at x ≈ 0.6, and an apparent change in the nature of the superconductivity from unconventional to conventional BCS at x ≈ 0.2. The compound $PrOs_4As_{12}$ undergoes transitions at 2.3 K and 2.2 K into two ordered phases, one of which appears to be antiferromagnetic in nature.

Keywords : filled skutterudites, heavy fermion, superconductivity, magnetic order, quadrupolar order, crystalline electric field