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"Hidden order," heavy electron ferromagnetism, and non-Fermi liquid behavior in the pseudoternary system $URu_{2-x}Re_xSi_2$[1]

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The identity of the ordered phase that occurs at temperatures below $T_o = 17$ K in the heavy fermion compound URu_2Si_2 has eluded researchers for two and a half decades. Features in various physical properties associated with this so-called "hidden order" (HO) phase are reminiscent of a charge or spin density wave that forms a gap over about 40% of the Fermi surface below T_o, while the remainder of the Fermi surface is gapped by the superconductivity below $T_c = 1.5$ K. In order to attain a better understanding of these phenomena, the physical properties of URu_2Si_2 have been studied as a function of applied pressure, chemical substitution, and magnetic field. Whereas the application of pressure suppresses the superconductivity and induces a phase transition from the HO phase to an antiferromagnetic phase, the substitution of Re for Ru results in the suppression of the superconductivity and the HO transition, the nearby emergence of ferromagnetic (FM) order, and unique critical behavior associated with the FM phase. Magnetization measurements on the $URu_{2-x}Re_xSi_2$ pseudoternary system as a function of x reveal the onset of ferromagnetism at a concentration $x_{cr} \approx 0.15$, which apparently represents a FM quantum critical point. Non-Fermi liquid (NFL) behavior in the physical properties such as the electrical resistivity and specific heat at low temperatures is found to extend deep into the FM region of the T - x phase diagram. Experiments conducted on $URu_{2-x}Re_xSi_2$ single crystals to investigate the superconducting, HO, and FM phases, characterize the NFL behavior, and establish the T - x phase diagram are described. The experimental results are compared to theoretical models for ferromagnetism in a Kondo lattice. Research performed in collaboration with N. P. Butch, J. R. Jeffries, B. T. Yukich, and D. A. Zocco

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