Title
Structure-property relationships in heavy fermion materials

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Structure–property relationships in heavy fermion materials*

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Heavy electron intermetallic compounds occur with elements having unstable 4f and 5f shells. The development of heavy electron behavior is strongly influenced by the local environment of the f-element. We discuss qualitatively aspects of the chemical physics of the occurrence of heavy electron materials as well as guides to prospecting for new materials.

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Spin fluctuations and heavy fermion ground states*

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A delicate balance exists in heavy fermion metals that can result in a magnetic, charge-density-wave or superconducting ground state. Neutron scattering is a sensitive measure of the electronic coupling that serves to compete with the predominant forces of f-electron localization. Recent observations of the spin-fluctuation spectrum in UPt_3, UBe_{13} and URu_2Si_2 will be described. They show that the heavy electrons can form a coherent ground state with a strongly q-dependent anisotropic spin response. A one-band isotropic Fermi liquid description is not in agreement with experiment. In some cases the spin response is in the form of sharp excitations. The question of whether the spin fluctuations provide the pairing boson will be discussed.

f-band narrowing in URh_3B_x

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Compounds of the type URh_3B_x have been prepared for $0 \leqslant x \leqslant 1$ and investigated by magnetic susceptibility, resistivity and heat capacity measurements. Room temperature X-ray data show that the metal lattice retains the Cu_3Au structure with the lattice constant changing from 3.991 Å for $x = 0$ to 4.152 Å for $x = 1$. Magnetic susceptibility measurements in the temperature range 5–300 K show a systematic change from exchange enhanced Pauli paramagnetism for $x = 0$ to a temperature dependent susceptibility having a peak at 10 K for $x = 0.9$ and 1. The electronic heat capacity coefficient γ increases from 15 mJ mol^{-1} K^2 for $x = 0$ to 120 mJ mol^{-1} K^2 for $x = 1$. For $x = 0.6$ and 0.9 the heat capacity shows a change in slope around 10 K. However, no clear jump, such as would be expected for a simple magnetic system, is seen. These results will be discussed in terms of changes in f electron hybridization, and a resulting narrowing of the f-band, due to an expansion of the lattice by boron.

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