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Unconventional superconductivity in novel d- and f-electron materials

M. Brian Maple
Department of Physics and Institute for Pure and Applied Physical Sciences
University of California, San Diego
La Jolla, CA 92093 USA
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A wide variety of strongly correlated electron ground states and phenomena are found in novel d- and f-electron materials: e.g., valence fluctuations, hybridization gap semiconductivity, heavy fermion behavior, non-Fermi liquid behavior, anisotropic superconductivity involving pairing of electrons in states with non-zero angular momentum, high temperature superconductivity, magnetic order, coexistence of superconductivity and magnetic order, quadrupolar order, etc. The occurrence in these materials of such a broad range of ground states and phenomena apparently arises from competing interactions that can be tuned by partial or complete substitution of one element for another, as well as the application of pressure and magnetic fields, resulting in rich and complex electronic phase diagrams in the hyperspace of temperature, chemical composition, pressure and magnetic field. In this talk, we describe several recent experiments on novel d- and f-electron materials that illustrate the delicate interplay between superconductivity and various charge and spin ordered states, such as charge density waves, spin density waves, magnetic order, and quadrupolar order, and the sensitivity of these states to changes in composition, pressure and magnetic field. Materials considered include the filled skutterudites MT_4X_{12} (M = alkali metal, alkaline earth, lanthanide, actinide; M = Fe, Ru, Os; X = P, As, Sb) [1], certain lanthanide (Ln) and actinide intermetallic compounds such as $URu_{2-x}Re_xSi_2$ [2] and $CeTIn_5$ (T = Co, Rh, Ir), and layered compounds such as $LnTe_3$ [3] and transition metal pnictides [4, 5]. This research was supported by the U.S. Department of Energy (DOE) under Grant Number DE-FG02-04ER46105, the National Nuclear Security Administration (NNSA) under the Stewardship Science Academic Alliance Program through the U.S. DOE under Grant Number DE-FG52-06NA26205, and the U.S. National Science Foundation under Grant Number DMR0802478.

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