Colloquium

EMERGENCE OF SUPERCONDUCTIVITY FROM MAGNETIC ORDER IN CORRELATED ELECTRON MATERIALS

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Wednesday, September 5 ❖ 4:00 P.M. ❖ 118 NSH

Refreshments at 3:30 P.M. in 202 NSH

Multinary compounds based on transition metal, rare earth, and actinide elements in which the localized d- and f-electron states are admixed with conduction electron states provide a wealth of strongly correlated electron phenomena: e.g., metal-insulator transitions, colossal magnetoresistance, valence fluctuations, hybridization gap semiconductivity, heavy fermion behavior, non-Fermi liquid behavior, unconventional superconductivity, magnetic order, quadrupolar order, etc. The occurrence of such a wide range of phenomena arises from a delicate interplay between competing interactions that can be tuned by variation of an external control parameter δ such as chemical composition x, pressure P, or magnetic field H, resulting in complex temperature T vs x, P, and H phase diagrams. A particularly striking phenomenon that has been observed in many correlated electron systems, including heavy fermion f-electron compounds, high T_c superconducting cuprates, and, more recently, many Febased materials, is the emergence of superconductivity near the critical value δ_{cr} of the control parameter (usually, x_{cr} or P_{cr}) where a magnetically ordered phase is suppressed to 0 K. For some systems, the Fermi liquid paradigm is found to be violated in the vicinity of δ_{cr}, which is manifested as weak power law and logarithmic divergences in the physical properties at low temperature (so-called non-Fermi liquid behavior). The superconductivity and the non-Fermi liquid behavior may be due to quantum fluctuations of the magnetic order parameter (OP) associated with the suppression of a second order magnetic phase transition to 0 K at δ_{cr}, where δ_{cr} is referred to as a quantum critical point (QCP). The formation of the superconducting phase appears to "protect" the QCP by removing the degeneracy associated with the OP fluctuations, and the superconducting electron pairing is apparently mediated by magnetic interactions. In contrast, magnetic interactions generally have a destructive effect on conventional BCS superconductivity. Interestingly, superconductivity has recently been found to emerge from charge ordered phases such as charge density waves. In this talk, we describe experiments, carried out in our laboratory, that address the interrelation between superconductivity, spin and charge order, and non-Fermi liquid behavior in novel d- and f-electron materials.

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