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Magnetism, Criticality and Superconductivity in Heavy-Fermion Compounds[1]

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Unraveling the interrelationship among magnetism, quantum criticality and unconventional superconductivity is a challenge that cuts across families of correlated electron materials, ranging from cuprate, iron-pnictide, and organic to heavy-fermion systems. Among these families, heavy-fermion compounds have served as prototypes of the interdependence, and among the heavy-fermion systems, the so-called Ce115s ($CeMIn_5$, M=Co, Rh, Ir) have been particularly instructive. The study of these and related Ce-based heavy-fermion materials has shown us clearly where to look for new unconventional superconductors – at a zero-temperature magnetic/non-magnetic boundary. In some examples, such as $CeRhIn_5$ and its derivatives, the quantum-critical state at this boundary can be unconventional, involving both fluctuations of a symmetry-breaking order parameter and a qualitative reconstruction of electronic states. Irrespective of whether the criticality is conventional or unconventional, the unconventional superconductivity that develops in its proximity also can be unstable toward the formation of magnetic order, presumably due to partial condensation of magnetic excitations at gap nodes. It seems possible that similar exotic states should appear in other strongly correlated electron systems. In collaboration with Y. K. Luo, D. Y. Kim, R. Movshovich, F. Ronning, P. F. S. Rosa, Q. Si and E. D. Bauer.

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