SEMINAIRE DE LA MATIERE CONDENSEE

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Superconductivity in Ferromagnets

Mardi 10 novembre 2009 à 14h 30
Salle de conférence 15 – Bâtiment 563

The emergence of superconducting states in pure materials around quantum critical points will be reviewed. Quantum critical points are found when continuous phase transitions between apparently simpler states can be made to occur at zero temperature. In practice continuous phase transitions almost always become discontinuous (first-order) as their transition temperatures are suppressed towards the absolute zero by varying a single parameter such as pressure. Several independent parameters then have to be tuned to approach a quantum critical point more closely. The strong magnetic anisotropy of URhGe allows multiple-parameter tuning to be achieved in practice with magnetic fields alone [1]. Remarkably, around the quantum critical point, an unusual form of superconductivity occurs (FIG 1). It is conjectured that parallel-spin electrons become paired, in contrast with anti-parallel spin-pairing found in almost all other superconductors. More remarkably still, although the superconductivity only forms below 0.5 K, it can survive in magnetic fields of over 30 T [2]. This provides one of the most dramatic examples of a growing number of correlated electronic states of matter formed close to quantum critical points.

The talk will review the experimental evidence that superconductivity is indeed linked to a proximity to a quantum critical point in URhGe, that equal-spins are paired, and clues as to the possible symmetry of the superconducting order parameter. The nature of the magnetic fluctuations that may bring about superconductivity will also be discussed. Finally, URhGe will be compared with two other superconducting ferromagnets, UCoGe and UGe_2 under pressure.

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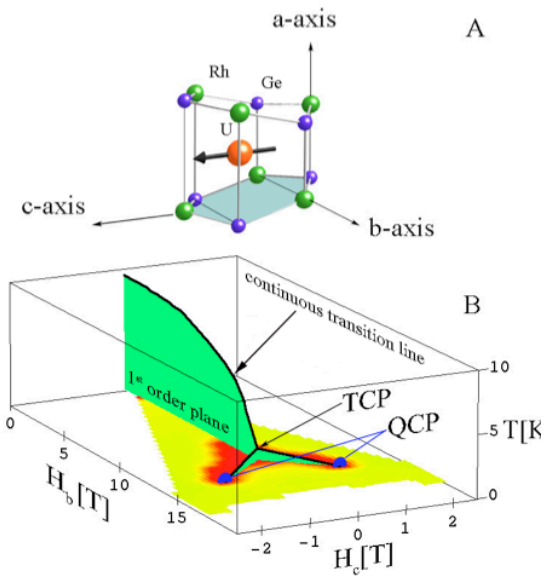

FIG 1: (A) The upper panel shows the structural building block of URhGe. The arrow shows the direction of the ferromagnetic moment in low applied magnetic field. (B) The lower panel shows the phase diagram for field in the bc plane. The component of the moment parallel to c changes sign discontinuously crossing the vertical (green) plane. The colour of the horizontal plane gives the resistivity at 50mK: red (dark) corresponds to superconductivity and yellow (lighter colour) to metallic conductivity. The position of quantum critical points (QCPs) and a tri-critical point (TCP) are labeled [3].

[1] F. Lévy, I. Sheikin, B. Grenier, and A. D. Huxley, Magnetic Field-Induced Superconductivity in the Ferromagnet URhGe, Science 309 (2005), 1343–1346.
[2] F. Lévy, I. Sheikin, and A. Huxley, Acute enhancement of the upper critical field for superconductivity approaching a quantum critical point in URhGe, Nature Physics 3 (2007), 460–3.
[3] A.D. Huxley, S.J.C. Yates, F. Lévy, and I. Sheikin, Odd-parity superconductivity and the ferromagnetic quantum critical point, J. Phys Soc Japan 76 (2007), 0510111–7.

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