From quantum criticality to field induced superconductivity

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The emergence of new electronic states in pure materials around quantum critical points will be reviewed. Such 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. NMR and potentially MSR can be used to reveal this change. In many cases the change from a continuous to a discontinuous transition occurs at sufficiently low temperature that new state formation is still achieved. More generally several independent parameters might have to be tuned to approach a quantum critical point more closely. The strong magnetic anisotropy of URhGe allows multiple-parameter magnetic-tuning to be realised in practice [1]. Remarkably, around the quantum critical point attained, an unusual form of superconductivity occurs: 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 new electronic states of matter formed close to quantum critical points with novel properties. MSR provides an important tool for characterising magnetic fluctuations that might drive state formation as well as for investigating the nature of the exotic states themselves.

[1] F. Lévy et al., Science, 309 (2005) 1343
[2] F. Lévy et al., Nature Physics. 3 (2007) 460