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Tuning magnetism by Kondo effect and frustration

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Heavy-fermion systems are an ideal playground for studying the quantum phase transition (QPT) between paramagnetic and magnetically ordered ground states arising from the competition between Kondo and RKKY interactions [1]. Two different routes have been identified by various experiments, i. e., the more traditional spin-density-wave (SDW) [2] and the Kondo-breakdown [3] approaches. However, up to now an *a-priori* assignment of a given system to these different routes has not been possible. Yet another route to quantum criticality not included in the above approaches might be geometric frustration of magnetic moments, a route well known for insulating magnets with competing interactions [4]. First experiments on metallic systems have recently been conducted. In the canonical partially frustrated antiferromagnetic system $CePd_{1-x}Ni_xAl$, the Néel temperature $T_N(x)$ decreases, with $T_N \to 0$ at the critical concentration $x_c \approx 0.144$. The low-temperature specific heat $C(T)$ evolves toward $C/T\alpha \ \ln(T_0/T)$ for $x \to x_c$ [5]. The unusual T dependence of C/T is compatible with the Hertz-Millis-Moriya (HMM) scenario of quantum criticality [2] if the quantum-critical fluctuations are two-dimensional in nature. Here two-dimensionality might arise from antiferromagnetic planes that are effectively decoupled by the frustrated Ce atoms in between. An exciting possibility is that the planes of frustrated Ce moments form a two-dimensional spin liquid. In the prototypical heavy-fermion system $CeCu_{6-x}Au_x$ the experiments by Schröder et al.[6] provided the initial evidence of local quantum criticality. While concentration and pressure tuning of the quantum phase transition (QPT) are described by this scenario, magnetic-field tuning the QPT is in line with the SDW scenario [7]. Elastic neutron scattering experiments on $CeCu_{5.5}Au_{0.5}$ under hydrostatic pressure p [8] show that at $p = 8$ kbar, T_N and the magnetic propagation vector attain almost the values of $CeCu_{5.7}Au_{0.3}$. This $x - p$ analogy away from the QPT is highly remarkable since the ambient-pressure magnetic structures for $x = 0.3$ and 0.5 are quite different. These results give clues to a general (x,p,B) phase diagram at $T = 0$ and might explain the existence of different universality classes.

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