THERMODYNAMIC SIMILARITIES BETWEEN $YbInCu_4$ AND $U(Ru_{0.96}Rh_{0.04})_2Si_2$

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Specific heat (Cp) and magnetocaloric effect (MCE) at the phase boundary into the single magnetic field-induced phase (phase II) of $U(Ru_{0.96}Rh_{0.04})_2Si_2$ yield striking similarities to the valence transition of $Yb_{1-x}Y_xInCu_4$ (see Fig.1). Unlike the valence instabilities in $Yb_{1-x}Y_xInCu_4$ however, the transition into phase II is of 2nd order in pure URu_2Si_2 thus indicating a broken symmetry. It evolves into a large 1st order anomaly only as phase II grows to dominate the phase diagram on Rh-doping [1].

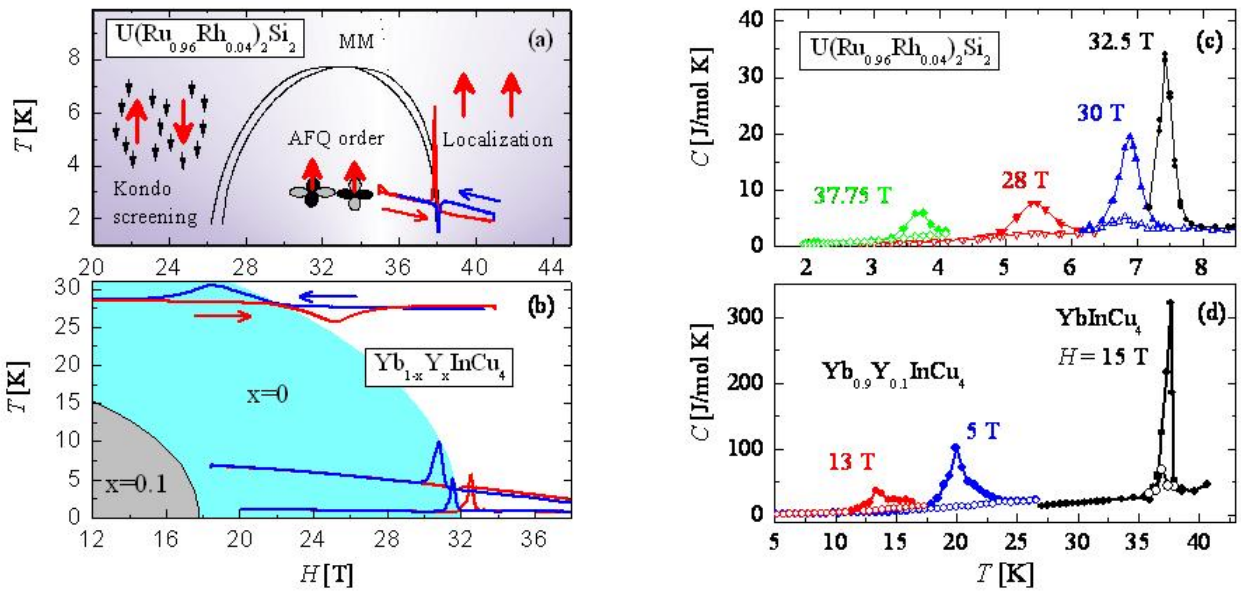

Figure 1. (a) Phase diagram of $U(Ru_{0.96}Rh_{0.04})_2Si_2$. MM stands for metamagnetic transition. Red and blue lines indicate the MCE rescaled x 25 showing a clear asymmetry between up- and down- field sweeps. (b) Phase diagram of $Yb_{1-x}Y_xInCu_4$ and corresponding MCE measurements rescaled x 2. Cp(T) measured on (c) $U(Ru_{0.96}Rh_{0.04})_2Si_2$ and (d) $Yb_{1-x}Y_xInCu_4$. Solid symbols represent Cp measured with the first heat pulse on warming-up while open symbols represent the average of subsequent heat pulses.

Phase II appears when the local 5f moments become liberated by the suppression of T* (i.e. heavy Fermi liquid bandwidth). At this point an effective antiferromagnetic (AF) exchange interaction prevents the Γ_5 moments from full alignment along the direction of H. A canted pseudospin phase results from the competition between H and the AF exchange. This corresponds to a large Z-component (uniform magnetization) along the field direction with a finite XY-component that orders according to the exchange interaction. A staggered quadrupolar moment (XY-component of the Γ_5 doublet) is then the most natural candidate for the order parameter of phase II. This scenario also explains why phase II is first induced and later suppressed as a function of increasing field. Such a broken symmetry order parameter, here involving a change in lattice parameters so as to change the degree of hybridization within phase II, would provide a rather effective bootstrap mechanism for both ensuring its stability and causing the transition to become 1st order like that in $YbInCu_4$.

References

[1] Silhanek, A.V., *et al.*, cond-mat/0507484.