

Suppression of ferromagnetism in URhGe doped with Ru



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INTRODUCTION

The correlated metal URhGe

- Orthorhombic TiNiSi-type structure (space group P_{nma})
- Low-temperature ordered moment $\sim 0.4 \mu_B/\text{U-atom}$ (oriented along c-axis); $\gamma = 155 \text{ mJ/molK}^2$
- Coexistence of Superconductivity ($T_{SC} = 0.25 \text{ K}$) and Ferromagnetism ($T_C = 9.5 \text{ K}$) at ambient pressure [1]

SC mediated by FM fluctuations $\rightarrow$ to be interesting to study magnetic fluctuations at QCP

Can we tune URhGe to critical point?

Applying external pressure [2,3]

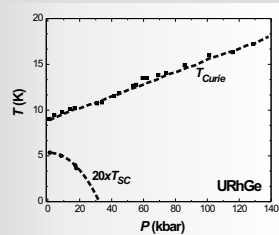
• Results in:

- (1) Increases 5f-electron hybridization and ligand states $\rightarrow$ reduction of local moment
- (2) Hybridization enhances the exchange coupling $\rightarrow$ strengthening magnetic order

The latter mechanism may prevail

$\Rightarrow T_C$ increases with 0.065 K/kbar

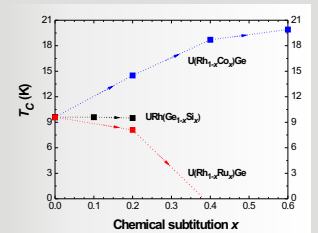
• $P_{\text{crit}} = -135 \text{ kbar}$



Chemical substitution

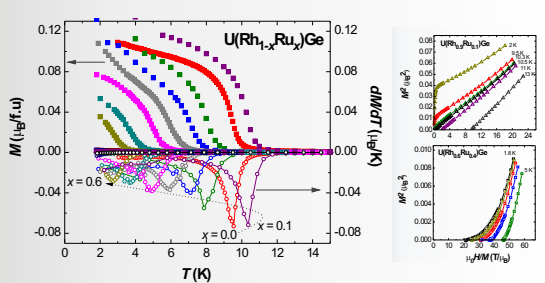
We substitute Ru, Co, Si $\rightarrow T_C$ can be tuned to zero by alloying URhGe by Ru

$\Rightarrow$ Investigate properties of polycrystalline $\text{U(Rh}_{1-x}\text{Ru}_x)\text{Ge}$ series over a wide range of x value ($0 \leq x \leq 0.6$) [4]



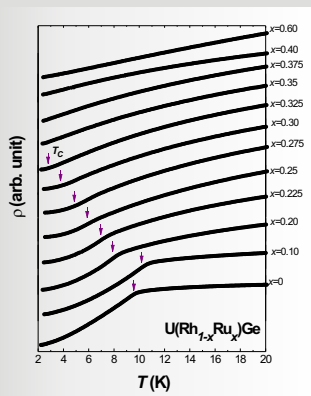
RESULTS

Magnetization



Low-temperature part of the magnetization measured in a field of 0.01 T
 T_C determined as a minimum of $-dM/dT$ as well as by Arrott plots

Resistivity

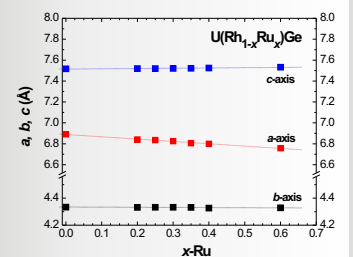


Temperature dependence of the electrical resistivity below 20 K
 T_C defined by a pronounced maximum in $d\rho/dT$

- For $x \geq 0.35$, we could not detect ferromagnetism in the measured temperature interval ($1.8 \text{ K} \leq T \leq 300 \text{ K}$)
- T_C initially increases up to 10.5 K for $x=0.10$
- T_C decreases from $x=0.20$ onwards
- For $x \geq 0.40$, absence of ferromagnetic ground state demonstrated by Arrott plots

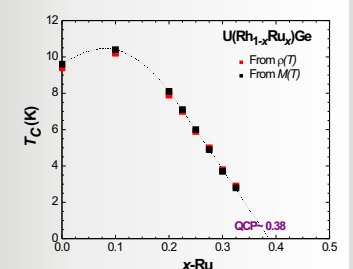
Lattice parameters

The anisotropic unit cell reduction is dominated by the decrease of the a-lattice parameter



T-x phase diagram

- $x \leq 0.1$, T_C enhanced by induced-pressure effect(?)
- $x > 0.1$, T_C linearly decreases with a slope $-0.43 \text{ K/at. \% Ru}$
Possible reasons:
 - Anisotropic hybridization
 - d-band emptying
 - Disorder (Griffiths phase model)
- Ferromagnetic order vanishes at $x \approx 0.38$



SUMMARY

- Ferromagnetism in URhGe is suppressed by Ru alloying
- QCP is estimated at $x \approx 0.38$

Further studies

- Measure resistivity and specific heat at lower temperatures ($T < 1.8 \text{ K}$)
- Investigate quantum critical behavior and compare with theory:
 - Itinerant Ferromagnet QCP: $T_C \sim x^{3/4}$, $\rho \sim T^{5/3}$, $c(T)/T \sim \ln T$
 - Griffiths phase model: $\rho \sim T^{-1+\lambda}$, $c(T)/T \sim T^{-1+\lambda}$ ($\lambda < 1$)
- Study inelastic neutron scattering for $x \approx 0.38$ on single crystal

References

- [1] D. Aoki et al., Nature **413** (2001) 613
- [2] S. Sakarya et al., Phys. Rev. B **67** (2003) 144407
- [3] F. Hardy et al., Physica B **359-361** (2005) 1111
- [4] S. Sakarya et al., Cond-mat/0507068