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 ~0.4 μ_B/U-atom (oriented along *c*-axis)
- Large linear term of specific heat γ=0.155 J/molK^2
- At ambient pressure coexistence of superconductivity (T_{SC}=0.25 K) and ferromagnetism (T_C=9.5 K) [1]

SC mediated by FM fluctuations

→ interesting to study magnetic fluctuations at QCP

Can we tune URhGe to critical point?

Applying external pressure [2,3]

- Results in:

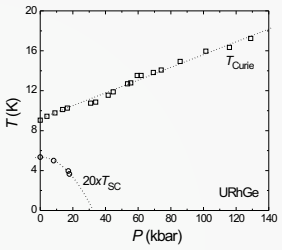
(1) Increases *5f*-electron hybridization and ligand states→ reduction of local moment

(2) Hybridization enhances the exchange coupling→ strengthening magnetic order

The latter mechanism may prevail

⇒ T_C increases with 0.065 K/kbar

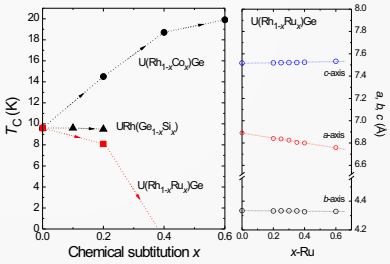
- P_{crit}= -135 kbar



Chemical substitution

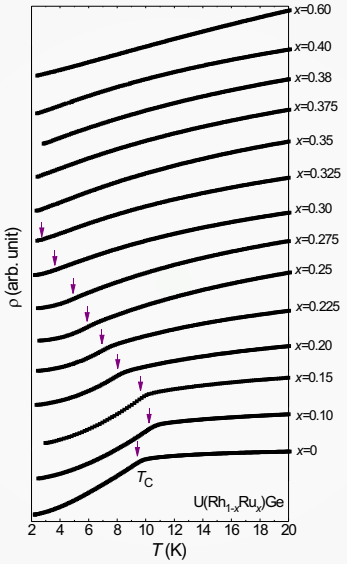
We substitute Ru, Co, Si → T_C can be tuned to zero by alloying URhGe by Ru

⇒ Investigate properties of poly-crystalline U(Rh$_{1-x}$Ru$_x$)Ge series over a wide range of *x* value (0≤*x*≤0.6) [4]



RESULTS

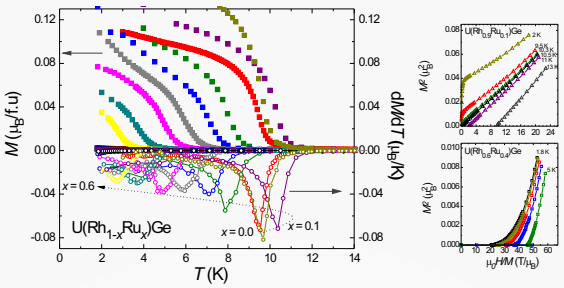
Resistivity



Temperature dependence of the electrical resistivity below 20 K

T_C defined by a pronounced maximum in dρ/dT

Magnetization

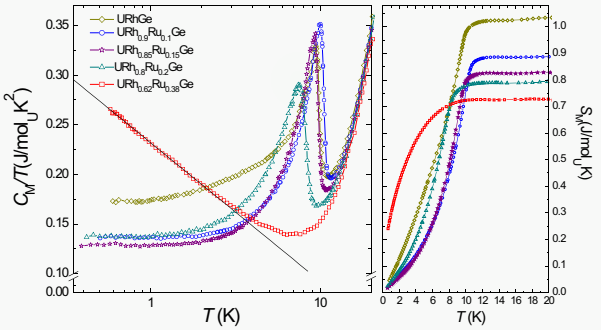


Low-temperature part of the magnetization measured in a field of 0.01 T

T_C determined as a minimum of -dM/dT as well as by Arrott plots

- For *x*≥0.35, we could not detect ferromagnetism in the measured temperature interval (1.8 K≤T≤ 300 K)
- T_C initially increases up to 10.5 K for *x*=0.10
- T_C decreases from *x*=0.15 onwards
- For *x*≥0.40, absence of ferromagnetic ground state demonstrated by Arrott plots

Specific heat



Temperature dependences of the specific heat and magnetic entropy

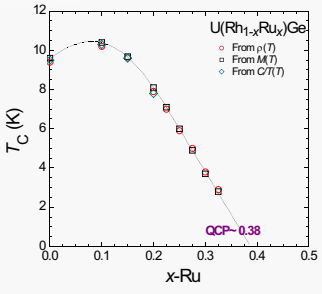
x=0; 0.10; 0.15; 0.20; 0.38 (S_M obtained by integration of C_M/T)

- The magnetic entropy S_M≈0.18*R*ln2 (J/mol$_U$K^2) reduced with *x*-Ru
- For *x*=0.38, $C/T(T)$~ln(T) at low temperature, following theory of Itinerant Ferromagnetic QCP

T-*x* phase diagram

- *x*≤0.1, T_C enhanced by induced-pressure effect(?)
- *x*>0.1, T_C linearly decreases with a slope -0.43K/at.%Ru

  Possible reasons:
  - *Anisotropic hybridization*
  - *d-band emptying*
- Ferromagnetic order vanishes at *x*=0.38



SUMMARY

- **Ferromagnetism in URhGe is suppressed by Ru alloying, the magnetic order vanishes at *x*=0.38**
- **Specific data consistent with FM QCP**

Further studies

- Measuring resistivity at lower temperatures (T<1.8 K) and compare with FM QCP theory, $\rho \sim T^{5/3}$
- Study inelastic neutron scattering and other properties for *x*=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