

# Posudek práce

předložené na Matematicko-fyzikální fakultě  
Univerzity Karlovy v Praze

- posudek vedoucího       posudek oponenta  
 bakalářské práce       diplomové práce

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Název práce: **Supravodivost a magnetismus uranových sloučenin**

Studijní program a obor: Fyzika, Fyzika kondenzovaných soustav a materiálů

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Jméno a tituly oponenta: Dr. rer. nat. Jeroen Custers

Pracoviště: Katedra fyziky kondenzovaných látek

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## Odborná úroveň práce:

- vynikající    velmi dobrá    průměrná    podprůměrná    nevyhovující

## Věcné chyby:

- téměř žádné    vzhledem k rozsahu přiměřený počet    méně podstatné četné    závažné

## Výsledky:

- originální    původní i převzaté    netriviální kompilace    citované z literatury    opsané

## Rozsah práce:

- veliký    standardní    dostatečný    nedostatečný

## Grafická, jazyková a formální úroveň:

- vynikající    velmi dobrá    průměrná    podprůměrná    nevyhovující

## Tiskové chyby:

- téměř žádné    vzhledem k rozsahu a tématu přiměřený počet    četné

## Celková úroveň práce:

- vynikající    velmi dobrá    průměrná    podprůměrná    nevyhovující

### Slovní vyjádření, komentáře a připomínky vedoucího/oponenta:

The title of this thesis writes Superconductivity and Magnetism of Uranium Compounds. In particular the interplay of ferromagnetism and superconductivity is a rather new field with many interesting phenomena, for example field-re-entrant superconductivity in URhGe. To understand the occurrence of such new forms of exotic phases, it is of importance to uncover the mechanisms responsible for it. So far the origin seems to be the closeness of the respective compound to a second order phase transition at zero temperature, a so called Quantum Critical Point. This leads to questions about the exact ground state properties of these quantum critical materials. Here the candidate focuses on the UCoRu compound, a weak ferromagnet with  $T_c \sim 3\text{K}$  and a superconducting transition at  $T_{SC} \sim 0.6\text{K}$ . As shown by the candidate by substituting Ru on the Co-site the compound can be tuned to its Quantum Critical Point where ferromagnetism disappears at  $T = 0$ . In this respect, the candidate's neutron results on  $\text{UCo}_{0.88}\text{Ru}_{0.12}$  discover that also the Co site should be taken into account.

The first chapters of the thesis cover an introduction to the physical phenomena in Uranium-based compounds. The Hill limit is mentioned, magnetism is discussed extensively and a good part of the chapter is devoted to quantum critical phenomena. Superconductivity is briefly discussed at the end as it is not a relevant issue of the thesis. This theoretical part is followed by an overview of Uranium based ferromagnetic superconductors and compounds similar to UCoGe. A detailed overview of the used methods for sample growth and experimental techniques is outlined in chapter 4. It contains a good explanation for the use of polarized neutron diffraction.

The main part of the thesis shows the experimental results. Chapter 5 is split into two sections; 5.1 covers the investigation on the polycrystals of the substitution series  $\text{UCo}_{1-x}\text{Ru}_x\text{Ge}$  with  $x \geq 0.1$ , while in section 5.2 results on a single crystal with  $x = 0.12$  are presented. A few points of criticism, however, are appropriate; Error bars are missing in general, plotting negative temperature (Fig. 5.15) is unphysical, and information about  $RRR$  and  $\rho_0$  values is omitted while these are basic measures to define the quality of samples. A comparison of results on the single crystal and polycrystals is not given neither confronting the results with literature (for example the pressure dependence of  $T_c$ ). In addition some steps in analyzing data are missing, like calculating the Grüneisen parameter. It is pity the candidate doesn't present data on  $\text{UCo}_{1-x}\text{Ru}_x\text{Ge}$  with  $x > 0.31$ , which respect to quantum criticality are interesting. Data are interpreted mainly in the view of NFL-behavior according to a single theory. A good example is Fig 5.12, where  $C/T$  is fitted by a  $\log T$  behavior while a square root behavior might be more appropriate. Similar is with resistivity data. A  $\rho \sim T^{1.2}$  is expected for disordered systems. The candidate should keep in mind that presenting the weakness of a theory helps to improve it.

In conclusion, despite the mentioned shortcomings this thesis contains a large amount of original material. The clarity of the manuscript is excellent. The candidate has demonstrated a high degree of expertise in a variety of experimental methods. The results are explained in a very satisfactory fashion. I have no hesitation in recommending that this thesis fulfills the requirements meriting the award of Mgr. from the Charles University in Prague.

### Případné otázky při obhajobě a náměty do diskuze:

- 1) On page 50 it is stated "the reduction of the magnetic entropy indicates a more itinerant nature of the magnetism near QCP". Please enlighten this statement.
- 2) In simple „Hill limit“ picture the shorting of the U-U distance would increase the possibility of superconductivity. Could you give a reason(s) why no SC in  $\text{UCo}_{1-x}\text{Ru}_x\text{Ge}$  is observed?

### Práci

- doporučuji  
 nedoporučuji

uznat jako diplomovou/bakalářskou.

### Navrhuji hodnocení stupněm:

- výborně  velmi dobře  dobře  neprospěl/a

Místo, datum a podpis vedoucího/oponenta: Praha, 2.5.2013