



## UvA-DARE (Digital Academic Repository)

### Ferromagnetism, superconductivity and quantum criticality in uranium intermetallics

Nguyen Thanh, H.

**Publication date**  
2008

[Link to publication](#)

#### **Citation for published version (APA):**

Nguyen Thanh, H. (2008). *Ferromagnetism, superconductivity and quantum criticality in uranium intermetallics*. [Thesis, fully internal, Universiteit van Amsterdam].

#### **General rights**

It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

#### **Disclaimer/Complaints regulations**

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: <https://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.

# Contents

<b>1. Introduction</b> .....	<b>1</b>
1.1. General introduction.....	1
1.2. Outline.....	3
<b>2. Experimental</b> .....	<b>5</b>
2.1. Sample preparation.....	5
2.2. Sample characterization.....	6
2.3. Magnetization measurement.....	6
2.4. Resistivity measurement.....	7
2.5. ac-susceptibility measurement.....	8
2.6. Specific-heat measurements.....	9
2.7. Muon spin relaxation and rotation.....	10
<b>3. Theoretical aspects</b> .....	<b>11</b>
3.1. Fermi liquid and non-Fermi liquid behavior.....	11
3.1.1. Fermi liquid behavior.....	11
3.1.2. Non-Fermi liquid behavior.....	14
3.2. Quantum phase transitions.....	16
3.2.1. Classical versus quantum phase transitions.....	16
3.2.2. Magnetic quantum phase transition in heavy fermion systems.....	20
3.2.3. Tricritical behavior.....	22
3.3. Ferromagnetic superconductor.....	23
3.3.1. Spin fluctuation and superconductivity.....	26
3.3.2. Order parameter.....	27
<b>4. A ferromagnetic quantum critical point in URhGe doped with Ru</b> .....	<b>29</b>
4.1. Introduction.....	29
4.2. Sample preparation and characterization.....	31

4.3. Magnetic properties.....	33
4.4. Electrical resistivity.....	40
4.5. Specific heat.....	44
4.6. ac-susceptibility.....	47
4.7. Discussion.....	49
4.7.1. The magnetic phase diagram.....	49
4.7.2. Hybridization phenomena.....	50
4.7.3. Ferromagnetic quantum critical point.....	51
<b>5. Ferromagnetic quantum critical point in single-crystalline URh<sub>0.62</sub>Ru<sub>0.38</sub>Ge...</b>	<b>53</b>
5.1. Introduction.....	53
5.2. Sample preparation and characterization.....	53
5.3. Electrical resistivity.....	55
5.4. Magnetic properties.....	56
5.5. Specific heat.....	58
5.6. Discussion.....	60
<b>6. Evolution of magnetism in URhGe doped with Si and Co.....</b>	<b>62</b>
6.1. Introduction.....	62
6.2. URhGe <sub>1-x</sub> Si <sub>x</sub> .....	63
6.2.1. Sample preparation and characterization.....	63
6.2.2. Magnetization.....	63
6.2.3. Electrical resistivity.....	66
6.3. URh <sub>1-x</sub> Co <sub>x</sub> Ge.....	67
6.3.1. Sample preparation and characterization.....	67
6.3.2. Magnetization.....	68
6.3.3. Electrical resistivity.....	73
6.4. Discussion.....	75
<b>7. Coexistence of ferromagnetism and superconductivity in UCoGe.....</b>	<b>77</b>
7.1. Introduction.....	77
7.2. Polycrystalline UCoGe.....	78
7.2.1. Sample preparation and characterization .....	78
7.2.2. Magnetization.....	79

7.2.3. Electrical resistivity.....	80
7.2.4. ac-susceptibility.....	83
7.2.5. Specific heat.....	84
7.2.6. Muon spin relaxation and rotation.....	86
7.2.7. Upper critical field $B_{c2}$ .....	91
7.2.8. Discussion.....	93
7.3. Single crystalline UCoGe.....	97
7.3.1. Sample preparation and characterization.....	97
7.3.2. Magnetic properties.....	99
7.3.3. Unusual upper critical field $B_{c2}$ .....	101
7.3.4. Discussion.....	106
7.4. Conclusion.....	107
<b>8. Suppression of Ferromagnetism and Superconductivity in UCoGe by doped with Si.....</b>	<b>108</b>
8.1. Introduction.....	108
8.2. Sample preparation and characterization.....	109
8.3. Magnetic properties.....	111
8.4. Electrical resistivity.....	113
8.5. ac-susceptibility.....	115
8.6. Discussion.....	117
8.6.1. $T$ - $x$ phase diagram.....	117
8.6.2. Hybridization phenomena.....	118
8.6.3. Dependence of superconductivity on disorder.....	118
<b>Summary.....</b>	<b>121</b>
<b>Samenvatting.....</b>	<b>124</b>
<b>Bibliography.....</b>	<b>128</b>
<b>List of publications.....</b>	<b>136</b>
<b>Acknowledgements.....</b>	<b>138</b>