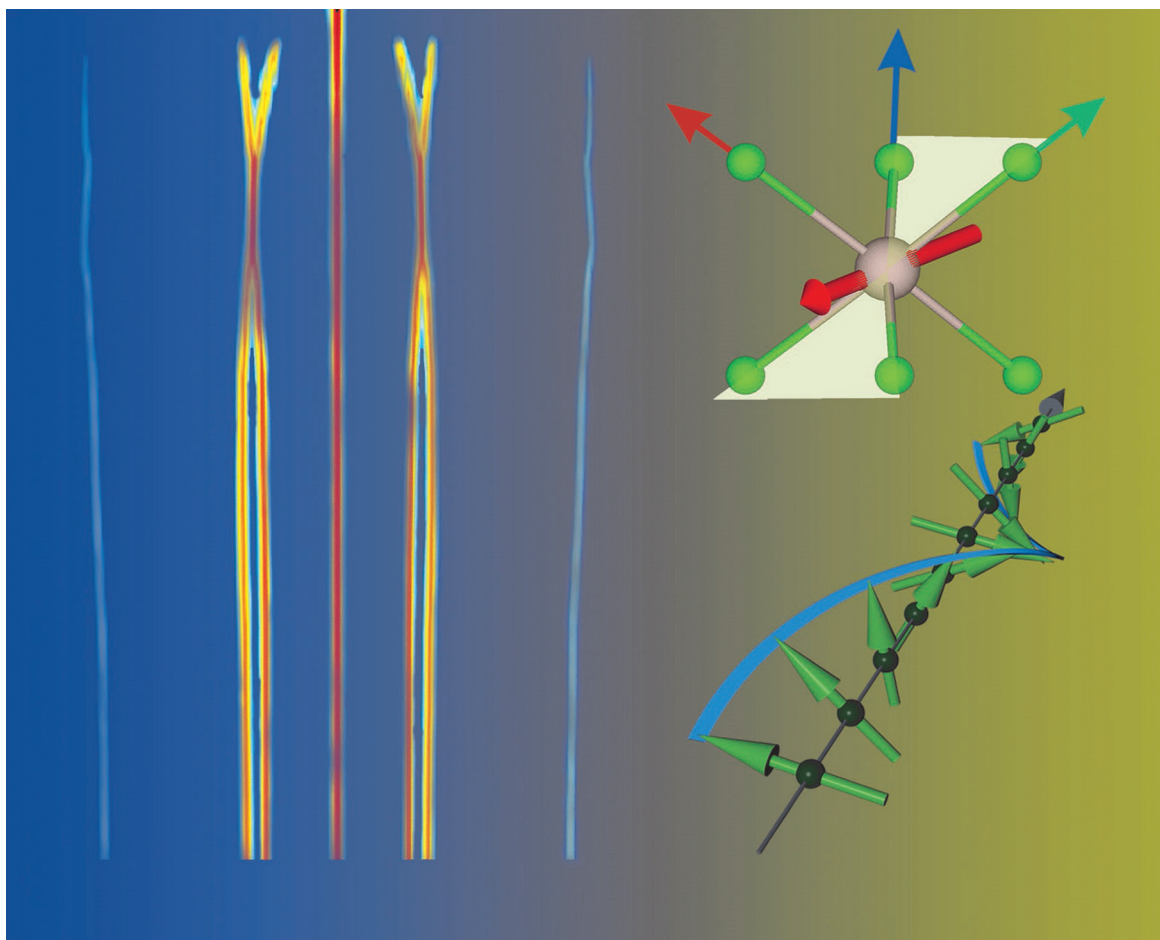




Single crystal growth and neutron scattering studies of novel quantum materials

Xiao Wang

Schlüsseltechnologien / Key Technologies

Band / Volume 239

ISBN 978-3-95806-546-8

Forschungszentrum Jülich GmbH
Jülich Centre for Neutron Science (JCNS)
Neutronenmethoden (JCNS-4)

Single crystal growth and neutron scattering studies of novel quantum materials

Xiao Wang

Schriften des Forschungszentrums Jülich
Reihe Schlüsseltechnologien / Key Technologies

Band / Volume 239

ISSN 1866-1807

ISBN 978-3-95806-546-8

1	Introduction	1
2	Scientific Background: Quantum Materials	3
2.1	Topological materials	5
2.1.1	Topological insulators	5
2.1.2	Topological semimetals	7
2.2	Anomalous Hall effect	10
2.2.1	Intrinsic anomalous Hall effect	11
2.2.2	Symmetry conditions for the intrinsic anomalous Hall effect	12
2.2.3	Scalar spin chirality and topological Hall effect	16
2.3	Frustrated magnets and exotic states of matter	17
2.3.1	Quantum spin liquid states	19
2.3.2	Kitaev materials	22
3	Experimental Techniques and Theory	27
3.1	Single crystal growth	27
3.1.1	An overview	27
3.1.2	Crystal growth methods	28
3.2	Neutron scattering theory	36
3.2.1	General neutron scattering theory	37
3.3	Neutron scattering instruments	42
3.4	Physical properties measurement	46
3.5	Magnetic structure determinations from neutron diffraction	47
3.5.1	Magnetic space groups	47
3.5.2	Group representation analysis of magnetic structure	48
4	Mn₃Sn	53
4.1	Introduction	53
4.2	Single crystal growth	54
4.3	Chemical composition determination	57
4.4	Magnetic properties of Mn ₃ Sn	59
4.5	Electrical transport properties of Mn ₃ Sn	62
4.6	Neutron diffraction	64
4.6.1	Magnetic structure at room temperature	64
4.6.2	Polarised analysis of DNS	67
4.6.3	High resolution neutron diffraction study of modulated phases	73
4.6.4	Magnetic structure of Mn ₃ Sn at 225 K	77
4.7	Discussion	80
4.7.1	Sample comparison between the samples in this work and old Bridgmann samples	80
4.7.2	Reasons for non-coplanar order	81

CONTENTS

4.7.3	Reasons for absence of AHE in the low temperature	82
4.8	Conclusion	84
5	α-RuCl₃	85
5.1	Single crystal growth of α -RuCl ₃	85
5.2	Heat capacity	87
5.3	Crystal structure and magnetic structure determination	88
5.3.1	Structural transition in α -RuCl ₃	88
5.3.2	Structure determination at low temperature	90
5.3.3	Spherical neutron polarisation analysis of magnetic structure	94
5.4	Neutron diffraction study of α -RuCl ₃ under isostatic pressures	101
5.4.1	Experiment preparation and setup	102
5.4.2	Magnetic phase transition under isostatic pressures	105
5.5	Conclusion	117
6	Summary and Outlook	119
6.1	Summary	119
6.2	Outlook	122
	Bibliography	123
A	Appendix	137
A.1	Summary of crystal growth experiments	137
A.2	Glossary	143
	Acknowledgments	145

Schlüsseltechnologien / Key Technologies
Band / Volume 239
ISBN 978-3-95806-546-8