



Spin- and orbital-dependent band structure of unconventional topological semimetals

Kenta Hagiwara

Schlüsseltechnologien / Key Technologies

Band / Volume 270

ISBN 978-3-95806-701-1

Forschungszentrum Jülich GmbH
Peter Grünberg Institut (PGI)
Elektronische Eigenschaften (PGI-6)

Spin- and orbital-dependent band structure of unconventional topological semimetals

Kenta Hagiwara

Schriften des Forschungszentrums Jülich
Reihe Schlüsseltechnologien / Key Technologies

Band / Volume 270

ISSN 1866-1807

ISBN 978-3-95806-701-1

Contents

Kurzzusammenfassung	iii
Abstract	v
1 Introduction	1
2 Background	5
2.1 Relativistic quantum mechanics	5
2.1.1 Dirac and Weyl fermions	5
2.1.2 Spin-orbit coupling	6
2.2 Classification of topological quantum materials	7
2.2.1 Overview	7
2.2.2 Chern number	9
2.2.3 Bulk-boundary correspondence	11
2.3 Topological insulators	12
2.3.1 Band structures of a time-reversal symmetric system	12
2.3.2 Z_2 topological insulators	13
2.4 Dirac and Weyl semimetals	15
2.4.1 Weyl semimetals	15
2.4.2 Properties of Weyl semimetals	16
2.4.3 Dirac semimetals	18
2.4.4 Type-II topological semimetal	18
2.4.5 Topological semimetals in transition-metal dichalcogenides	19
2.5 Chiral topological semimetals	23
2.5.1 Unconventional fermions	23
2.5.2 Kramers-Weyl fermions	24
2.5.3 Chiral topological semimetals in transition-metal monosilicides	24
3 Experimental methods	29
3.1 Photoemission spectroscopy	29
3.1.1 General description	29
3.1.2 Free electron final state model	32
3.1.3 Photoemission process	32
3.1.4 Surface sensitivity	34
3.2 Momentum microscopy	34
3.2.1 Overview	34
3.2.2 Working principles	37

3.2.3	Momentum microscopy vs. ARPES	38
3.3	Spin-resolved momentum microscopy	39
3.3.1	Principle of electron spin detection	39
3.3.2	Imaging spin filter	41
3.4	Polarization	44
3.4.1	Effect of the matrix element	44
3.4.2	Circular dichroism	48
3.4.3	Linear dichroism	51
3.5	NanoESCA beamline	53
4	Type-II Dirac semimetal NiTe₂	55
4.1	Sample preparation	55
4.2	Fermi surface tomography	55
4.3	Band structure	59
4.4	Spin texture	61
4.5	Summary	63
5	Type-II Weyl semimetal MoTe₂	65
5.1	Sample preparation	65
5.2	Experimental geometry	68
5.3	Circular dichroism of the Weyl states	69
5.4	Spin texture	73
5.5	Summary	75
6	Chiral topological semimetal CoSi	77
6.1	Sample preparation	77
6.2	Photon-energy dependence	80
6.3	Dichroism and orbital contribution in the band structure	81
6.4	Summary	87
7	Discussion	89
7.1	Overview	89
7.2	Spin texture of the Dirac and Weyl cones	90
7.3	Symmetry-reflected spin texture in transition-metal dichalcogenides	93
7.4	Orbital texture of topological bands	96
8	Conclusion and outlook	99
	Bibliography	101
	Acknowledgement	119

Schlüsseltechnologien / Key Technologies

Band / Volume 270

ISBN 978-3-95806-701-1

Mitglied der Helmholtz-Gemeinschaft

