

Contents

1	Introduction	1
1.1	Historical Overview	1
1.2	Localized Heisenberg Magnets	3
1.2.1	Mean Field Approximation	3
1.2.2	Phase Transitions of Heisenberg Magnets and Spin Amplitude Conservation	6
1.3	Band Theoretical Approach	11
1.3.1	Hartree–Fock Approximation	12
1.3.2	Free Energy of Stoner-Wohlfarth Theory	13
1.4	Magnetic Properties Derived from the SW Theory	15
1.5	Summary	17
	References	19
2	Fluctuations and Magnetism	21
2.1	Fluctuations	21
2.2	Fluctuations and Responses	23
2.2.1	Kramers-Kronig Relation	26
2.3	SCR Spin Fluctuation Theory	26
2.3.1	Free Energy of the SCR Theory	27
2.3.2	Curie–Weiss Law of Magnetic Susceptibility	31
2.4	Discontinuous Change of Magnetization	33
2.4.1	Temperature Dependence of Magnetization	33
2.4.2	Origin of the Discontinuity	35
2.5	Thermal and Zero-Point Spin Fluctuation Amplitudes	36
2.5.1	Spectral Properties of Spin Fluctuation Amplitudes	38
2.5.2	Thermal Spin Fluctuation Amplitude	39
2.5.3	Zero-Point Spin Fluctuation Amplitude	41
2.6	Spin Amplitude Conservation	42
2.6.1	Neutron Scattering Experiment on MnSi	43
2.6.2	Theoretical Explanation for Experiments on MnSi	46
2.6.3	Giant Magnetic Fluctuations Observed in (Y,Sc)Mn ₂	47
2.7	Summary	48
	References	48

3	Effects of Spin Fluctuations on Magnetic Properties	49
3.1	Basic Idea of the Spin Fluctuation Theory	49
3.2	Magnetic Isotherm in the Ground State	50
3.2.1	Magnetic Isotherm for Ferromagnets	51
3.2.2	Magnetic Isotherm for Exchange Enhanced Paramagnets	54
3.3	Magnetic Properties in the Paramagnetic Phase	55
3.3.1	Temperature Dependence of Magnetic Susceptibility	55
3.3.2	Magnetic Susceptibility in the Low Temperature Limit	56
3.3.3	Magnetic Susceptibility Around the Critical Point	57
3.3.4	Curie–Weiss Law of Magnetic Susceptibility	58
3.3.5	Magnetic Isotherm in the Paramagnetic Phase	61
3.4	Critical Magnetic Behaviors	64
3.4.1	Critical Magnetic Isotherm	64
3.4.2	Scaling Law Relations Among Critical Indexes	68
3.5	Crossover Behavior Around the Quantum Critical Point	69
3.5.1	Scaling Function	69
3.5.2	Temperature Induced Crossover Between Classical and Quantum Critical Phenomena	71
3.5.3	Temperature Dependence of Magnetic Susceptibility of Paramagnets Near the QC Point	71
3.5.4	Magnetic Susceptibility of Paramagnets Around the Quantum Critical Point	75
3.6	Summary	76
	References	77
4	Magnetic Properties in the Ordered Phase	79
4.1	Initial Value Problem	79
4.1.1	Analytic Property of Thermal Amplitude	80
4.1.2	Effect of the Presence of Spin Waves	81
4.2	Temperature Dependence of Spontaneous Moment	85
4.2.1	Magnetic Properties at Low Temperatures	85
4.2.2	Comparison with Experiments at Low Temperatures	87
4.2.3	Magnetic Properties Around the Critical Temperature	92
4.2.4	Numerical Results of Temperature Dependence	93
4.2.5	Magnetization Curve	93
4.3	Summary	96
	References	97
5	Thermal Properties of Itinerant Magnets	99
5.1	Difficulties Involved in the Spin Fluctuation Theory of Specific Heat	99

5.2	Free Energy of Spin Fluctuations	100
5.2.1	Free Energy in the Presence of Magnetic Moment	100
5.2.2	Stability Conditions of the Free Energy	101
5.2.3	Free Energy Corrections	102
5.3	Temperature Dependence of Entropy and Specific Heat	104
5.3.1	Temperature Dependence of Paramagnetic Entropy	105
5.3.2	Temperature Dependence of the Specific Heat	106
5.3.3	Temperature Dependence of the Entropy and the Specific Heat in the Ordered Phase	109
5.4	Specific Heat Under the External Magnetic Field	114
5.4.1	Maxwell Relation	114
5.4.2	Temperature Derivatives in the Static External Magnetic Field	117
5.4.3	Entropy and Specific Heat in the Paramagnetic Phase	118
5.4.4	External Field Effect in the Ordered Phase	122
5.4.5	Numerical Estimate	125
5.4.6	External Field Effect on Paramagnets Near the QCP	128
5.5	Summary	129
	References	130
6	Magneto Volume Effect	131
6.1	Introduction	131
6.1.1	Thermal Expansion Due to Lattice Vibrations	132
6.2	Stoner-Edwards-Wohlfarth Theory and its Correction	133
6.2.1	SEW Theory of Magneto-Volume Effect	133
6.2.2	Correction of the Free Energy of Spin Fluctuations	135
6.3	Volume Dependence of the Free Energy	138
6.3.1	Magnetic Grüneisen Parameters	141
6.3.2	Forced Magneto-Striction and Maxwell Relation	143
6.4	Volume Magneto-Striction for Ferromagnets	144
6.4.1	Magneto-Volume Effect in the Ground State	144
6.4.2	Ferromagnets at Finite Temperatures	145
6.5	Magneto-Volume Effect in Some Temperature Ranges	151
6.5.1	Magneto-Volume Effect at Low Temperature and Grüneisen Relation	152
6.5.2	Around the Critical Point	154
6.5.3	In the Paramagnetic Phase	158
6.5.4	Numerical Results on Volume-Strictions	161
6.6	Magneto-Volume Effect for Paramagnets	162
6.6.1	Spontaneous Magneto-Striction for Paramagnets	164
6.6.2	Forced Magneto-Striction for Paramagnets	166
6.7	Pressure Effects on Spontaneous Magnetic Moment and the Critical Temperature	167
6.7.1	Effect of Pressure on the Critical Temperature	167

6.7.2	Pressure Effect Measurements of Spontaneous Magnetic Moment and Critical Temperature.	170
6.8	Summary of Magneto-Volume Effects	174
	References	176
Index	179

Spin Fluctuation Theory of Itinerant Electron Magnetism

Takahashi, Y.

2013, XI, 181 p., Hardcover

ISBN: 978-3-642-36665-9