

Contents

1	Introduction	1
	References	5
2	Spin Models	7
2.1	Spin Angular Momentum	7
2.2	Coupled Spins	10
2.3	Two Interacting Spin- $\frac{1}{2}$'s	11
2.4	Commutators and Quantum Numbers	14
2.5	Physical Picture	16
2.6	Infinite Arrays of Spins	16
2.7	1D Heisenberg Chain with $S = \frac{1}{2}$ and Nearest-Neighbour Interaction	18
	References	19
3	Quantum Treatment of the Spin-$\frac{1}{2}$ Chain	21
3.1	General Remarks	21
3.2	Aligned State	22
3.3	Single Deviation States	23
3.4	Two Deviation States	27
3.4.1	Form of the States	33
3.5	Three Deviation States	36
3.5.1	Bethe Ansatz for $S_T^Z = \frac{N}{2} - 3$	36
3.6	States with an Arbitrary Number of Deviations	37
	Reference	38
4	The Antiferromagnetic Ground State	39
4.1	The Fundamental Integral Equation	39
4.2	Solution of the Fundamental Integral Equation	43
4.3	The Ground State Energy	45
	References	47

5	Antiferromagnetic Spin Waves	49
5.1	The Basic Formalism	49
5.2	Magnetic Field Behaviour	57
	References	59
6	The XY Model	61
6.1	Introduction	61
6.2	Change from Spin Operators to Fermion Operators	62
6.3	Fourier Transform	68
6.4	Quasiparticle Operators	69
6.5	Quasiparticle Energies	71
6.6	Ground State Energy of the XY-Model	73
	References	75
7	Spin-Wave Theory	77
7.1	Introduction	77
7.2	Ferromagnetic Spin-Wave Theory	80
7.3	Antiferromagnetic Spin-Wave Theory	82
	References	88
8	Numerical Finite-Size Calculations	89
8.1	Introduction	89
8.2	A Simple Example	90
8.3	Results in 1D	92
8.4	Results in 2D	95
	References	96
9	Other Approximate Methods	99
9.1	Introduction	99
9.2	Variational Method	99
9.3	Variational Monte Carlo Method	101
9.4	The Green Function Monte Carlo Method	104
9.5	Perturbation Theory	105
	References	108
10	The Coupled Cluster Method	109
10.1	Introduction	109
10.2	The CCM Formalism	110
10.3	The XXZ-Model	115
10.3.1	The LSUB2 Approximation for the Spin-Half, Square-Lattice XXZ-Model for the z-Aligned Model State	117

10.3.2	The SUB2 Approximation for the Spin-Half, Square-Lattice XXZ-Model of the z -Aligned Model State	122
10.3.3	High-Order CCM Calculations Using a Computational Approach	125
10.3.4	Excitation Spectrum of the Spin-Half Square-Lattice XXZ-Model for the z -Aligned Model State	127
10.4	The Lattice Magnetisation	129
	References	134
11	Quantum Magnetism	135
11.1	Introduction	135
11.2	One-Dimensional Models	136
11.2.1	The Spin-Half J_1 - J_2 Model on the Linear Chain	136
11.2.2	The $s = 1$ Heisenberg Model on the Linear Chain	138
11.2.3	The $s = 1$ Heisenberg-Biquadratic Model on the Linear Chain	139
11.3	The $s = 1/2$ Heisenberg Model for Archimedean Lattices	140
11.4	Spin Plateaux	145
11.5	The Spin-Half J_1 - J_2 Model on the Square Lattice	146
11.6	The Shastry-Sutherland Antiferromagnet	147
11.7	Conclusions	149
	References	150
	Index	153

An Introduction to Quantum Spin Systems

Parkinson, J.B.; Farnell, D.J.J.

2010, XI, 154 p. 22 illus., Softcover

ISBN: 978-3-642-13289-6