

Contents

	<i>Preface</i>	<i>page ix</i>
1	Introduction	1
	1.1 Background and motivation	1
	1.2 Outline of the book	6
	1.3 General references	7
2	Basic MHD	9
	2.1 The induction equation	9
	2.2 Kinematic MHD	17
	2.3 The Lorentz force	26
	2.4 Kinematic dynamos	31
3	Linearized Boussinesq magnetoconvection	38
	3.1 Onset of convection in a vertical magnetic field	39
	3.2 Inclined magnetic fields	50
	3.3 Other boundary conditions	60
4	The nonlinear regime	64
	4.1 Weakly nonlinear behaviour	66
	4.2 Bifurcations from nonlinear solutions	78
	4.3 Period-doubling and chaos at a heteroclinic bifurcation	92
	4.4 Travelling waves	105
	4.5 Transverse rolls in a horizontal field	109
5	2D Boussinesq magnetoconvection	113
	5.1 Numerical results: Cartesian geometry	113
	5.2 Axisymmetric magnetoconvection	134
	5.3 Transitions to chaos	144
	5.4 Shearing instabilities	152
	5.5 Localized patterns, snaking and convectons	158
	5.6 The strong field limit	172
	5.7 Inclined magnetic fields	176

viii	<i>Contents</i>	
6	3D Boussinesq magnetoconvection	180
6.1	Pattern selection	181
6.2	Convection and small-scale dynamos	198
6.3	Fully nonlinear magnetoconvection	206
6.4	The strong field regime	211
7	Magnetoconvection, rotation and the dynamo	215
7.1	Linear theory of rotating convection and magnetoconvection	216
7.2	Dynamos due to nonlinear rotating convection in a layer	229
7.3	Dynamos in spherical shells	240
7.4	Laboratory dynamos	246
8	Compressible magnetoconvection	251
8.1	The fully compressible regime	252
8.2	Two-dimensional behaviour	258
8.3	Three-dimensional behaviour	278
8.4	Inclined magnetic fields	307
9	Solar and stellar magnetic fields	320
9.1	Global magnetic activity	321
9.2	Photospheric magnetoconvection	330
9.3	Magnetoconvection in sunspots	338
9.4	From simple idealized models to massive nonlinear computations	347
	Appendix A The Boussinesq and anelastic approximations	349
A.1	The Boussinesq approximation	350
A.2	The anelastic approximation	352
A.3	The strong anelastic approximation	353
	Appendix B Chaotic systems	355
B.1	The logistic map	355
B.2	The Lorenz equations	356
B.3	The Shilnikov bifurcation	358
	Appendix C Double-diffusive convection	360
C.1	Chaos in 2D thermosolutal convection	360
C.2	Low-order model systems	365
	Appendix D Magnetic buoyancy and the magneto-Boussinesq approximation	367
	<i>References</i>	370
	<i>Index</i>	395