

Contents

Preface	xi
Introduction	xv
The importance of words and of formulae	xix
The vocabulary of fusion plasma science	xxiii
PART 1: FUSION IN THE COSMOS	1
1 Plasmas	3
1.1 The secrets of plasmas	3
1.2 Plasma physics peculiarities and games	6
2 Nuclear fusion	10
2.1 Nuclear fusion reactions	10
2.2 Nuclear fusion plasmas	12
3 The cosmos	16
3.1 Fusion in the cosmos	16
3.2 How it all began . . .	17
3.3 Galaxies and stars	20
3.4 The Sun's metabolism	24
4 The plasma universe	30
4.1 Around the Sun	30
4.1.1 The magnetoplasma revolution	30
4.1.2 The challenge of space plasma exploration	35
4.1.3 Cosmic plasma jets	37
4.1.4 The all-pervasive Alfvén wave	41

viii	<i>Contents</i>		<i>Contents</i>	ix
	4.1.5 The dynamic face of the Sun	43	8.2 Instabilities	107
	4.1.6 Solar flares and prominences	45	8.3 The concepts of direct and indirect drive	107
	4.1.7 Comets	49	8.4 Laser fusion	108
4.2	The Sun–Earth interplay	54	8.5 Ion beam drivers	110
	4.2.1 The solar wind	54	9 The fusion reactor	113
	4.2.2 The Earth’s magnetosphere	57	9.1 Reactor requirements	113
	4.2.3 The ionosphere	60	9.2 Reactor design	114
	4.2.4 Auroras	62	9.3 Heating and confinement	114
4.3	Beyond the Sun	64	10 Outlook into the future	116
	4.3.1 Supernovas	64	Conclusions—the great fusion plant	120
	4.3.2 Pulsars: lighthouses of the cosmos	65	Afterword	121
	4.3.3 Quasars	67	Acknowledgments	128
5	Electrical discharges	71	Appendix 1	130
	5.1 Applications of plasmas	71	Appendix 2	132
			Appendix 3	133
	PART 2: FUSION ON EARTH	75	Glossary	137
6	Dynamic fine structure of plasmas	77	Short fusion–plasma dictionary	140
	6.1 Modelling as a tool for interpretation and prediction	77	Subject index	153
	6.2 Waves and instabilities	79	Character index	157
	6.3 Nonlinear effects	83		
	6.4 Three-wave interaction	85		
	6.5 Evolution of populations: explosive instabilities	88		
	6.6 Vortices	90		
	6.7 Wavelets and turbulence	94		
	6.8 From fine structure to global dynamics of fusion plasmas	95		
7	The art of magnetic confinement	100		
	7.1 The principle of magnetic confinement	100		
	7.2 Fusion energy generation and self-sustained fusion	101		
	7.3 The architecture of magnetic confinement	102		
	7.4 History of alternative concepts	103		
	7.5 Stellarators and tokamaks	104		
8	Microballoon explosions by lasers: inertial confinement	106		
	8.1 The principle of inertial confinement	106		