

Contents

Foreword to the Second Edition	xi
Acknowledgments	xii
Prologue	1
1 Highlights to Plasma	5
1.1 Unveiling Matter	5
1.2 Unveiling the Atom	7
1.3 Unveiling the Electron	12
1.4 Unveiling the Nucleus	16
1.5 Unveiling a New State of Matter	21
2 What is Plasma?	22
2.1 Introducing Plasma	22
2.2 A Visit to an Exotic Nightclub	26
2.3 A Joint Ping-Pong Game	27
2.4 The One-Mile Run	29
2.5 Shielding	33
2.6 Collisions	34
2.7 Swallowing and Ejecting Photons	37
2.8 The Agents	39
2.9 Safekeeping	43
2.10 Plasma Reflections	44
2.11 Plasma Compendium	47
3 A Universe of Plasma	49
3.1 Plasma in the Beginning	49
3.2 The Universe	52
3.3 The Magnetosphere	56
3.4 Light From the Stars	60
3.5 The Star's Interior	63
3.6 The Solar Exterior	66

3.7	A Supernova Explosion	70
3.8	Synchrotron Radiation	72
3.9	Comets	75
3.10	From the Visual to the Plasma Universe	76
4	Plasma in Industry	79
4.1	Understanding Plasma for Application in Industry	79
4.2	Semiconductor Electronics	86
4.3	Plasma Modification of Materials	87
4.4	Plasma Spray	89
4.5	Plasma Welding, Cutting and Material Processing	92
4.6	Plasma Space Propulsion	93
4.7	Plasma Display Panels	94
4.8	Plasma and the Diamond Industry	94
4.9	Plasma and Treating Wastes	95
4.10	Plasma Lighting	96
4.11	Particle Accelerators and Plasma	98
4.12	X-Ray Lasers	99
4.13	Plasma Isotope Separation	100
4.14	Plasma Antennas	101
4.15	More Efficient, Unique, More Environmentally Clean	101
5	The Solution to the Energy Problem	103
5.1	Soylent Green	103
5.2	World Energy Consumption	106
5.3	Nuclear Energy	107
5.4	Nuclear Fusion Energy	108
5.5	Conditions for Nuclear Fusion	115
5.6	Ignition Temperature	118
5.7	Magnetic Confinement—Magnetic Bottles	119
5.8	Plasma Diffusion	120
5.9	Plasma Instabilities	122
5.10	Plasma Formation	124
5.11	Plasma Heating	124
5.12	The Tokamak	126
5.13	Magnetic Mirrors	129
5.14	Nuclear Fusion Reactors	130
5.15	Inertial Confinement with Lasers	132
5.16	Particle Beam Fusion	142
5.17	Advantages of Nuclear Fusion Energy	143
5.18	The Transition to the Fusion Era	144
5.19	TFTR, JET and other Magnetic Fusion Devices	147
5.20	Indirect Drive for Inertial Fusion Energy	149
5.21	Fast Ignitors	151

5.22	The Z-Pinch	152
5.23	Outlook	153
6	...More History of Plasma Physics	154
6.1	Plasma Without Realization	154
6.2	Realizing the Fourth State of Matter – Plasma	155
6.3	Controlled Lightning	157
6.4	The Ionosphere – A Plasma Mirror for Radio Signals	159
6.5	Plasma in Space	160
6.6	The Sun's 'Secret' Source of Energy	161
6.7	Splitting the Atom – Fission	162
6.8	Fusion – The Synthesis of Light Nuclei	163
6.9	Solving the Energy Problem for the Generations Ahead	165
6.10	The Beginning of Controlled Nuclear Fusion in the USA	166
6.11	The Beginning of Nuclear Fusion in Britain and the Soviet Union	168
6.12	International Declassification of Controlled Nuclear Fusion	169
6.13	Landmarks in the Development of Plasma Physics	171
	Appendix: Rhyming Verses	175
	Epilogue	191
	Glossary	193
	Bibliography	210
	Index	215