

CONTENTS

CHAPTER 1. EXPERIMENTAL RESEARCH ON HIGH-TEMPERATURE PLASMAS	1
1-1 Introduction	1
1-2 The problem of controlled nuclear fusion	2
1-3 The experimental configurations used at Los Alamos Scientific Laboratory	3
1-4 The problem of runaway	7
1-5 Excitation of plasma oscillations	10
1-6 Experiments in the United Kingdom on plasma dynamics	10
1-7 Magnetohydrodynamic experiments with liquid mercury	12
1-8 Experiments with liquid metals	13
1-9 Experiments with electric shock tubes	13
CHAPTER 2. THE PROBLEMS OF THERMONUCLEAR FUSION AND HIGH-TEMPERATURE PLASMAS	19
2-1 The stable confinement of hot plasmas	19
2-2 The generation and heating of plasmas	25
2-3 Plasma statistics	27
2-4 Radiation losses from hot plasma	30
2-5 Further remarks on radiation losses	45
2-6 A differing view of the radiation problem	46
CHAPTER 3. GASEOUS ELECTRONICS PHENOMENA	54
3-1 Introduction	54
3-2 Phenomenological behavior of a plasma	54
3-3 Plasma sheaths	57
3-4 Highly ionized plasmas	65
3-5 Review of several magnetohydrodynamic experiments	70
CHAPTER 4. THE DYNAMICS OF ELECTRON BEAMS	78
4-1 Introduction	78
4-2 Interaction mechanisms leading to amplification	79
4-3 Analytical methods	84
4-4 Periodic circuits and periodic electron beams	95
4-5 Interactions of electron beams in crossed electric and magnetic fields	98
4-6 Velocity distribution effects in electron beams	101
4-7 Nonlinear effects in electron beam dynamics	106
4-8 Interaction between an electron beam and a plasma	107
4-9 Scattering of electromagnetic waves from an ionized column	111
4-10 Guided wave propagation along a cylindrical plasma column	114

CHAPTER 5. STATISTICAL PLASMA MECHANICS	119
5-1 Introduction	119
5-2 The Boltzmann equation	121
5-3 Equations of transfer (moments of the Boltzmann equation)	123
5-4 Expansion of the distribution function	124
5-5 Additional definitions	126
5-6 Resulting equations	128
5-7 Alternative form of the equations of motion	131
5-8 Other procedures used in the deduction of transfer equations	133
5-9 Problems concerning electron beams	137
5-10 Flow without collisions in a magnetic field. Parker's "modified hydromagnetic equation"	140
5-11 Flow in the direction of the magnetic flux	144
5-12 Anisotropy of the pressure tensor	146
5-13 Electric conductivity and heat flow	149
5-14 Electric conductivity and heat flow. (Cont.)	151
5-15 The "runaway" phenomenon	155
5-16 Plasma diffusion in a magnetic field	157
5-17 Phenomena of thermal diffusion	160
5-18 Comments on the validity of the Boltzmann equation. Its relation to the two-particle distribution function and to the Fokker-Planck equation	164
5-19 Application of the two-particle distribution function. Relation to Boltzmann's expression for binary collisions	170
5-20 Reduction of the right side of Eq. (5-83) to an expression of the Fokker-Planck type	173
5-21 An expression of the Fokker-Planck type. (Cont.)	177
5-22 Coefficients of the Fokker-Planck expression. Mean loss of momentum. Debye potential field	179
5-23 Plasma oscillations. Collective coordinates	181
CHAPTER 6. CONTINUUM PLASMA DYNAMICS	187
6-1 Introduction	187
6-2 The equations of motion	188
6-3 Dimensionless parameters	190
6-4 The general structure of the equations of motion	191
6-5 Conservation laws for zero dissipation. The vorticity analogy	191
6-6 Characteristics	193
6-7 Waves in a fluid of finite conductivity	195
6-8 Shock waves	197
6-9 Switch-on shocks.	200
6-10 Magnetically produced shock waves, magnetohydrodynamic shock waves, and current sheets	201
6-11 Shock layers, shear layers, and plasma flow past solid bodies	202
6-12 An experiment on magnetohydrodynamic shock waves	203
6-13 The production of high-density plasmas	206

6-14 Experiments in a magnetically driven shock tube	218
6-15 Hydromagnetic shock waves	218
6-16 Shock-front problems	219
CHAPTER 7. FLIGHT MAGNETOHYDRODYNAMICS	221
7-1 Introduction: range of applicability of MHD to flight	221
7-2 A one-dimensional magnetohydrodynamic experiment	222
7-3 Magnetohydrodynamic drag and lift	227
CHAPTER 8. SOLAR, PLANETARY, AND INTERPLANETARY MAGNETOHYDRODYNAMICS	233
8-1 Plasmas and magnetic fields	233
8-2 Extended solar atmosphere	236
8-3 The extended terrestrial atmosphere	238
8-4 Suprathermal particles in interplanetary space	240
8-5 Dynamics of interplanetary gases. The solar wind	244
8-6 Interplanetary magnetic field	247
8-7 Solar wind in the geomagnetic field	251
8-8 Summary	254
8-9 Observed dynamical processes in interplanetary space	255
8-10 Cosmic-ray momentum spectrum	259
8-11 High-speed solar radio bursts	259
CHAPTER 9. COSMICAL MAGNETOHYDRODYNAMICS	264
9-1 Introduction	264
9-2 Cosmic magnetic fields and cosmic rays	264
9-3 Hydrodynamics of the interstellar gas	266
9-4 Interchange of matter between stars and gas.	269
9-5 The mass supply of the interstellar medium	270
9-6 Energy sources for turbulence in the interstellar gas	270
9-7 Amplification of the interstellar magnetic field	272
9-8 The plasma jet in Messier 87	274
9-9 Small, high-energy nuclei in galaxies	276
9-10 Wisps in the Crab Nebula	276
9-11 The acceleration of cosmic rays	277
9-12 Additional examples of hydromagnetic phenomena in astrophysics	278
9-13 The production of galactielike magnetohydrodynamics in the laboratory	279
BIBLIOGRAPHY	287
INDEX	363