

SOLAR SYSTEM MAGNETOHYDRODYNAMICS *

by

G. L. Siscoe

Department of Atmospheric Sciences

University of California

Los Angeles, CA 90024

* To appear in Proceedings of the 1982 Boston College Theory Institute in Solar-Terrestrial Physics, Robert L. Carovillano and Jeffrey M. Forbes, Editors, D. Reidel Publishing Co., Dordrecht-Holland.

TABLE OF CONTENTS

	Page
Chapter I	
THE MACROSCOPIC EQUATIONS OF A PLASMA	1
I.1 From Particles to Fluids	1
I.2 Phase Space Density	2
I.3 The Continuity Equation in Phase Space	2
I.4 The Boltzmann Equation	3
I.5 Liouville's theorem	4
I.6 Forming the Macroscopic Variables	4
I.7 Derivation of the Macroscopic Equations	4
I.8 The Field Equations	8
I.9 The Conservation Equations	10
I.10 Inclusion of Neutral Particle Interactions	12
I.11 The Prognostic Equation for Scalar Pressure	13
I.12 Temperature and Related Concepts	15
I.13 Return to the Prognostic Equation for Scalar Pressure	18
I.14 Adiabatic, Isentropic and Polytropic Flows	19
I.15 The Bernoulli Equation	20
I.16 Divergence of the Anisotropic Pressure Tensor	21
I.17 Single Particle Drifts and the Euler Equation	22
I.18 Limitations to the Use of the Macroscopic Equations	27
Chapter II	
THE HYDROMAGNETIC APPROXIMATION AND ITS CONSEQUENCES	28
II.1 The Generalized Ohm's Law	28
II.2 Charge Neutrality and Related Approximations	31
II.3 Poynting's Theorem in the Hydromagnetic Limit	33
II.4 Equipotential Fieldlines and Streamlines in Steady State Hydromagnetic Flows	33
II.5 Freezing Laws	36
II.6 Thawing of Magnetic Flux	38
II.7 The Generalized Vorticity Theorem	40
II.8 The MHD Helmholtz Equation	42
II.9 The Double Adiabatic Invariants	43
Chapter III	
MHD WAVES AND DISCONTINUITIES	47
III.1 Linearized Plane Waves in an Isotropic Magnetized Plasma ..	47
III.2 MHD Discontinuities	57
Contact Discontinuities	60
Tangential Discontinuities	60
Shock Waves 1: Ordinary (non-MHD) Shock Waves	61
Shock Waves 2: Parallel Shocks	64
Shock Waves 3: Perpendicular Shocks	64
Shock Waves 4: Oblique Intermediate Mode Shocks	66
Shock Waves 5: Oblique Fast and Slow Mode Shocks	67

	Page
Chapter IV	
MHD INSTABILITIES	70
IV.1 The Firehose and Mirror Instabilities	70
IV.2 The Kelvin-Helmholtz Instability	75
IV.3 The Magnetospheric Interchange Instability	82
References	90