



# Contents

## Chapter I

### History and Background

I.1	Introduction . . . . .	1
I.2	Indirect Evidence for the Existence of the Solar Wind . . . . .	1
I.3	The Extension of the Solar Corona into Interplanetary Space . . . . .	3
I.4	The Expansion of the Solar Corona into Interplanetary Space . . . . .	5
I.5	The Extension of the Solar Magnetic Field into Interplanetary Space . . . . .	11
I.6	An Alternative Model of the Coronal Expansion . . . . .	14
I.7	Confirmation of the Existence of the Solar Wind by <i>In Situ</i> Spacecraft Observations . . . . .	16

## Chapter II

### The Identification and Classification of Some Important Solar Wind Phenomena

II.1	Introduction . . . . .	20
II.2	The Classification of Solar Wind Phenomena . . . . .	21
II.3	An Identification, Description, and Classification of Some Solar Wind Phenomena . . . . .	25
	Persistent, High-Speed Solar Wind Streams . . . . .	25
	Flare-Produced Interplanetary Shock Waves . . . . .	26
	Interplanetary Filaments . . . . .	28
	Alfvén Waves . . . . .	29
	Hydromagnetic Discontinuities . . . . .	30
II.4	Summary and Plan of Action . . . . .	35

## Chapter III

### The Dynamics of a Structureless Coronal Expansion

III.1	Introduction . . . . .	36
III.2	In Search of the Structureless Solar Wind . . . . .	37
III.3	The Physical Properties of Low-Speed Solar Wind . . . . .	43
III.4	A “One-Fluid” Model of the Steady, Spherically-Symmetric Coronal Expansion . . . . .	45

III.5	A “Two-Fluid” Model of the Steady, Spherically-Symmetric Coronal Expansion . . . . .	49
III.6	A Comparison of Solar Wind Observations with Predictions of the Basic One-Fluid and Two Fluid-Models . . . . .	53
III.7	The Energetics of the Coronal Expansion . . . . .	55
III.8	The Effects of Hydromagnetic Waves on the Coronal Expansion . . . . .	61
III.9	The Effects of Magnetic Forces on the Coronal Expansion . . . . .	66
III.10	The Effects of the Magnetic Modification of Heat Conduction on the Coronal Expansion . . . . .	67
III.11	The Effects of Viscosity on the Coronal Expansion . . . . .	71
III.12	The Effects of Noncollisional Energy Exchange Mechanisms on the Coronal Expansion . . . . .	74
III.13	The Effects of a Reduced Thermal Conductivity on the Coronal Expansion . . . . .	75
III.14	Another Look at the Energetics of the Coronal Expansion . . . . .	80
III.15	Angular Momentum in the Coronal Expansion . . . . .	84
III.16	Evaporative Models of the Coronal Expansion . . . . .	90

## Chapter IV

### **Chemical Composition of the Expanding Coronal and Interplanetary Plasma**

IV.1	Introduction . . . . .	94
IV.2	The Determination of the Average Solar Wind Helium Abundance . . . . .	95
IV.3	A Comparison of the Solar and Interplanetary Helium Abundances . . . . .	100
IV.4	Theoretical Models of the Expansion of a Corona Containing Helium . . . . .	101
IV.5	The Relationship between the Photospheric and Coronal Helium Abundances . . . . .	107
IV.6	General Conclusions Regarding the Chemical Composition of the Expanding Solar Atmosphere. . . . .	108
IV.7	Observations of Solar Wind Ions Other than $^1\text{H}^+$ and $^4\text{He}^{++}$ . . . . .	109
IV.8	The Ionization State of Expanding Coronal Plasma . . . . .	114
	(1) Collisional Ionization by Electron Impact . . . . .	115
	(2) Radiative Recombination . . . . .	115
IV.9	Possible Interplanetary Modification of the Solar Wind Ionization State . . . . .	119

## Chapter V

### **High-Speed Plasma Streams and Magnetic Sectors**

V.1	Introduction . . . . .	121
V.2	Observed Features of High-Speed Plasma Streams . . . . .	121

Contents	XI
V.3 Observed Features of Magnetic Sectors . . . . .	125
V.4 The Relationship between High-Speed Plasma Streams and Magnetic Sectors . . . . .	131
V.5 Theoretical Models of Interplanetary Plasma Streams . . . . .	132
V.6 Theoretical Models of the Nonuniform, Hydromagnetic Coronal Expansion . . . . .	143
V.7 The Effects of High-Speed Plasma Streams on Average Solar Wind Characteristics . . . . .	155
V.8 Energy Transport in High-Speed Solar Wind Streams . . . . .	159
V.9 The Solar Sources of High-Speed Plasma Streams . . . . .	162

## Chapter VI

### Flare-Produced Interplanetary Shock Waves

VI.1 Introduction . . . . .	169
VI.2 The Motions of Interplanetary Shock Waves Inferred from Plasma Observations . . . . .	171
VI.3 Shock Configurations Inferred from Magnetic and Plasma Observations . . . . .	177
VI.4 Characteristics of the Post-Shock Plasma and Magnetic Field . . . . .	181
VI.5 The Chemical Composition of the Post-Shock Plasma . . . . .	184
VI.6 The Relationship between Solar Flares and Interplanetary Shock Waves . . . . .	187
VI.7 A Synthesis of Interplanetary Shock Observations . . . . .	191
VI.8 Theoretical Models of Shock Propagation in the Solar Wind . . . . .	192
VI.9 A Classification of Interplanetary Shock Waves Suggested by the Theoretical Models . . . . .	199
VI.10 The Mass and Energy in Interplanetary Shock Waves . . . . .	201
VI.11 The Role of Interplanetary Shock Waves in the Overall Mass and Energy Transport from the Corona . . . . .	206
VI.12 Implications Regarding the Physics of Solar Flares . . . . .	207

## Chapter VII

### Concluding Remarks

VII.1 Neglected Topics . . . . .	211
(1) Techniques of Solar Wind Observations . . . . .	211
(2) Small-Scale Interplanetary Phenomena . . . . .	211
(3) Extensions of the Coronal Expansion Concept . . . . .	211

(4) Solar Wind Interactions with Other Particles, Fields, and Planetary Bodies . . . . .	212
(5) Formal Aspects of the Solar Wind Equations . . . . .	212
(6) Heliographic Latitude Dependencies of Solar Wind Properties . . . . .	212
VII.2 Solar Activity and the Solar Wind . . . . .	213
<b>References</b> . . . . .	<b>216</b>
<b>Subject Index</b> . . . . .	<b>233</b>

