

Contents

List of Figures	xiii	
List of Tables	xxi	
Preface	xxiii	
1		
Solar and Solar Radio Effects on Technologies	1	
<i>Louis J. Lanzerotti</i>		
1	Introduction, and Some History	1
2	Electromagnetic Waves and Wireless	2
3	Solar-Terrestrial Effects on Technologies	5
4	Solar Radio Emissions	7
5	Contemporary Solar Radio and Some Implications for Technologies	8
5.1	Solar noise levels and technologies	8
5.2	Solar noise interference	10
5.3	Statistics of solar radio noise	11
6	Conclusion and Looking to the Future	13
References	15	
2		
Overview of Solar Radio Physics and Interplanetary Disturbances	17	
<i>Monique Pick</i>		
1	General Context of the Radio Emissions	19
2	Coronal Magnetography	20
3	Transient Activity and Flares	24
3.1	Energy dissipation	24
3.2	Solar magnetic reconnection in the solar atmosphere and diagnostics on regions of acceleration	25
3.3	Electron acceleration and transport during flares	28
4	Coronal Mass Ejections	30
4.1	Radio signatures of CMEs	31
4.1.1	Lift-off and angular spread in the corona of flare/CME event	32
4.1.2	Relationship with EUV dimming and coronal waves	34
4.1.3	Direct radio CME imaging	34

5	Coronal and Interplanetary Shocks, Flares and CMES	35
6	Interplanetary Coronal Mass Ejections	37
7	Solar Energetic Particle Events	39
8	Concluding Remarks and the Future of Radio Physics	41
	References	43
3		
	The Frequency Agile Solar Radiotelescope	47
	<i>T. S. Bastian</i>	
1	Introduction and Background	47
2	Preliminaries	49
	2.1 Radiative transfer	49
	2.2 Radio emission mechanisms	50
3	Overview of FASR Science	52
	3.1 Coronal magnetic fields	52
	3.2 The physics of flares	53
	3.3 Drivers of space weather	55
	3.4 The quiet Sun	56
	3.5 Synoptic measurements and forecasting	58
4	Description of the Instrument	59
	4.1 Operational basis	59
	4.2 FASR instrumental requirements	60
	4.3 System design overview	62
	4.3.1 Antenna configuration	63
	4.3.2 Antennas	64
	4.3.3 Feeds and front ends	64
	4.3.4 Signal transmission	65
	4.3.5 Signal processing	66
5	Operational Issues	66
6	Concluding Remarks	67
	References	68
4		
	Radio Spectral Diagnostics	71
	<i>Dale E. Gary, G. J. Hurford</i>	
1	Introduction	71
2	Characteristic Frequencies of the Solar Atmosphere	73
3	Plasma Emission Diagnostics	75
4	Free-Free Diagnostics	75
5	Gyroresonance Diagnostics	77
6	Gyrosynchrotron Diagnostics	81
7	Exotic Mechanisms	83
8	Conclusion	85
	References	86
5		
	Coronal Magnetic Field Measurements through Gyroresonance Emission	89

Stephen M. White

1	Coronal Magnetic Fields are Intrinsically 3D	90
2	Extrapolations of Surface Magnetic Fields	91
3	The Properties of Gyroresonance Emission	92
3.1	Physical mechanism	92
3.2	Opacity	93
4	Gyroresonance Radio Emission from Active Regions	96
4.1	Radio emission from a dipole magnetic field	96
4.2	The effect of viewing angle	98
4.3	Variation with frequency	98
5	Observational Examples	101
6	Applications of Gyroresonance Emission	104
6.1	Coronal magnetic field measurement	104
6.2	Simulations of FASR magnetic field measurements	106
6.3	Coronal currents	107
6.4	Tests of magnetic extrapolations	108
6.5	Heights of radio sources	111
7	Summary	111
	References	112

6

Coronal Magnetic Field Measurements Through Bremsstrahlung	115
--	-----

G.B.Gelfreich

1	Introduction	115
2	Basic Formulae	115
2.1	Equations of transfer	115
2.2	Basic expression for isotropic plasma	117
2.3	Basic expression for anisotropic plasma	117
3	Diagnostics of the Coronal Plasma	118
3.1	Diagnostics of the mechanism of the emission generated by thermal bremsstrahlung	118
3.2	Expressions for the magnetic field	119
3.3	Radio measurements of the magnetic field	120
4	Expected Parameters of Polarized Radio Emission	121
4.1	Optically thin regions	121
4.2	Optically thick regions	122
4.3	Combination of optically thin and thick regions	123
5	Radio Magnetograms of Solar Active Regions	124
6	Magnetic Fields in Prominences	125
7	Magnetic Fields in a Coronal Hole	127
8	Magnetic Fields in Coronal Loops	130
9	Future Development of the Method	131
	References	133

7

Coronal Magnetic Field Measurements Through QT-Propagation	135
--	-----

Boris Ryabov

1	Microwave QT-Propagation in the Solar Corona	135
1.1	Introduction	135
1.2	Effects of electromagnetic wave mode coupling	137
1.3	Geometry of QT-propagation	140
2	Results and Prospects of Microwave Observations	140
2.1	Regularities of the inversion phenomenon	141
2.2	Multiple inversion	144
2.3	Linear polarization in the outer corona	145
2.4	Oscillations	145
3	The Technique of Coronal Magnetography Through QT-Propagation	147
3.1	Normalization procedure	147
3.2	The source-QTR distance	148
3.3	Scrutiny of a coronal magnetogram	149
4	Summary and Conclusions	150
	References	151
8		
	Overview of Solar Flares	153
	<i>Hugh Hudson, Lyndsay Fletcher, Josef I. Khan and Takeo Kosugi</i>	
1	Introduction	154
2	New Observational Capabilities	154
2.1	<i>Yohkoh</i>	154
2.2	SOHO and TRACE; other facilities	155
3	The Flare Concept	155
3.1	Confined and LDE flares	156
3.2	Flares and CMEs	156
4	Flare Loops	157
4.1	Footpoints, coronal spectroscopy, and evaporation	158
4.2	Arcades	159
4.2.1	“Sigmoids” and filament cavities	162
4.3	Loop-loop interactions	163
5	Particle Acceleration	163
5.1	Footpoint sources	164
5.2	Coronal sources	164
5.3	Energetic ions	166
6	Ejections	166
6.1	Parallel and perpendicular flows	166
6.2	Dimming	167
6.3	Global waves	168
7	Microflares and Nanoflares	169
8	Evolution of Flare Theories and Models	172
9	Conclusions	172
	References	173
9		
	Electron Transport During Solar Flares	179
	<i>Jeongwoo Lee</i>	
1	Introduction	179

2	The Formulations	182
2.1	Trap-and-precipitation	182
2.2	Trap, bypass, and precipitation	183
3	Electron Trapping And Precipitation	184
3.1	Simple bursts	184
3.2	Trap or precipitation?	184
3.3	Extended and evolving trap	186
3.4	Trap without precipitation	187
4	Electron Pitch Angle Variation	189
4.1	Weak diffusion	189
4.2	Intermediate diffusion	191
4.3	Strong diffusion	193
4.4	Pitch angle scattering and MWR maps	196
5	Electron Energy Variation	197
6	Concluding Remarks	198
	References	200
10		
	Decimeter Burst Emission and Particle Acceleration	203
	<i>Arnold O. Benz</i>	
1	Introduction	204
2	The Decimeter Range	204
2.1	Spectral types and classifications	205
2.2	High-frequency limit of the decimeter range	209
2.3	Why decimetric radio bursts?	210
3	Hard X-rays and Decimeter Radiation	211
3.1	Decimetric type III bursts	211
3.2	Decimetric narrowband spikes	211
3.3	Drifting pulsating structures	212
3.4	Flares without radio emission	212
4	Flare Physics	214
4.1	Location of source regions	214
4.2	Evidence for reconnection	215
5	Emission Processes	217
5.1	Beam emissions	217
5.2	Emissions from the acceleration site	218
5.3	Decimetric spikes and pulsations	219
6	Conclusions	219
	References	220
11		
	Radio Observations of Coronal Mass Ejections	223
	<i>Angelos Vourlidas</i>	
1	Coronal Mass Ejections	223
1.1	A brief CME primer	223
1.2	Radio emissions associated with CMEs	225
1.2.1	Thermal free-free	225
1.2.2	Nonthermal gyrosynchrotron	226

12	1.2.3 Non-thermal plasma emissions	227
2	Radio CME Observations During Cycle 23	227
	2.1 CME detection	229
	2.2 CME development	229
	2.3 Detection of CME-associated structures	231
	2.4 Radio prominence eruptions	232
	2.5 Type II emission	233
	2.6 CME radio precursors	234
	2.7 Overview	234
3	FASR Connection	235
	3.1 Advantages of radio observations	235
	3.2 Disadvantages of current radio observations	236
	3.3 Instrument requirements	236
	References	239
13	Tomographic 3D-Modeling of the Solar Corona with FASR	243
	<i>Markus J. Aschwanden, David Alexander, Marc L. DeRosa</i>	
1	Introduction	244
2	Active Region Modeling	245
	2.1 Simulation of FASR images	245
	2.2 Peak brightness temperature	248
	2.3 Temperature and density diagnostic of loops	252
	2.4 Radio versus EUV and soft X-ray diagnostics	255
3	Chromospheric and Coronal Modeling	257
4	Future FASR Science	261
	References	262
14	Coronal Diagnostics with Radio and EUV/Soft X-Ray Observations	265
	<i>Jeffrey W. Brosius</i>	
1	Introduction	265
2	2D Coronal Magnetography	267
3	Diagnostics of Quasi-Transverse Layers	270
4	Coronal Iron Abundance	271
5	3D Coronal Magnetography	273
6	Future of Coordinated Radio and EUV/Soft X-ray Observations	281
	References	284
15	Radio Observations of the Quiet Sun	287
	<i>Christoph U. Keller and Säm Krucker</i>	
1	Introduction	287
2	Observing the quiet Sun at radio wavelengths	289
3	General appearance of the quiet Sun in radio waves	291
	3.1 Submillimeter observations	292
	3.2 Millimeter and microwave observations	292
4	Thermal stratification of the quiet Sun	294

5	Filaments and prominences	296
6	Coronal heating events in the quiet Sun	297
7	FASR and the quiet Sun	300
	References	301
15		
	Interplanetary Radio Bursts	305
	<i>N. Gopalswamy</i>	
1	Introduction	305
2	Type III Bursts	307
2.1	Isolated type III bursts	308
2.2	Complex type III bursts	309
2.2.1	Origin of nonthermal electrons	310
2.2.2	Complex type III bursts and CMEs	311
2.3	Type III storms	312
2.3.1	Cessation and recovery of type III storms	313
3	Type II Bursts	314
3.1	IP shocks, CMEs and type II radio bursts	316
3.1.1	DH type II bursts	317
3.2	Are type II bursts CME-driven?	318
3.3	What is a fast CME?	320
4	Recent Developments	323
4.1	Radio signatures of CME interaction	323
4.1.1	Radio signature solely due to CME interaction	323
4.1.2	Medium modification: Interaction between two fast CMEs	324
4.1.3	Interaction between CMEs with nearly equal speeds	325
4.1.4	What we mean by CME interaction	325
4.2	Unusual radio signatures	328
5	Concluding Remarks	329
	References	330
16		
	Solar Radar	335
	<i>William A. Coles</i>	
1	Introduction	335
2	Theory	336
3	Other Coronal Observations	342
4	Previous Radar Measurements	345
5	New Observations	348
6	Use of an Imaging Receiver	351
	References	352
17		
	Three-Dimensional Tomography Of Interplanetary Disturbances	355
	<i>Bernard V. Jackson, P. Paul Hick</i>	
1	Introduction	356
2	Global Data Analyses	358
2.1	IPS measurements	359

2.2	Helios spacecraft Thomson scattering measurements	362
3	Model and Tomographic Analysis	366
3.1	Solar wind model	367
3.2	Computer analysis	368
4	<i>In-situ</i> Comparisons	371
4.1	Reconstructed global observations	374
5	Conclusion	381
	References	382
	Index	387