

Contents

Part I Exoplanet Host Star Radiation and Plasma Environment

1	Exoplanet Host Star Radiation and Plasma Environment	3
	Jeffrey L. Linsky and Manuel Güdel	
1.1	Introduction: Relevance of Short Wavelength Radiation to Planetary Atmospheres	3
1.2	UV Radiation	5
1.3	EUV Radiation	9
1.4	X-Radiation.....	12
	Conclusions	16
	References.....	16
2	Stellar Winds in Time	19
	Brian E. Wood, Jeffrey L. Linsky, and Manuel Güdel	
2.1	Introduction: The Wind-Corona Connection.....	19
2.2	Observational Constraints on Stellar Winds	21
2.2.1	Upper Limits from Direct Detection Techniques	21
2.2.2	Stellar Wind Measurements from Astrospheric Absorption	22
2.2.3	T Tauri Star Winds.....	28
2.3	Expectations from Theoretical Models	30
	Conclusion	31
	References.....	32

3	Magnetic Fields and Winds of Planet Hosting Stars	37
	Theresa Lüftinger, Aline A. Vidotto, and Colin P. Johnstone	
3.1	Introduction: Stellar Magnetic Fields	37
3.2	Analyzing Stellar Magnetic Fields: Techniques	38
3.2.1	Zeeman Broadening and Spectropolarimetry	38
3.2.2	Zeeman Doppler Imaging	39
3.3	Rotation and Magnetism in Low Mass Main-Sequence Stars.....	40
3.3.1	The Sun	40
3.3.2	Solar Type Stars	41
3.3.3	M Dwarfs	42
3.3.4	Rotation and Magnetism	42
3.4	Low Mass Pre-Main-Sequence Stars	43
3.5	Winds Launched by Stellar Magnetic Fields.....	46
3.5.1	Stellar Magnetic Fields and Activity	46
3.5.2	Winds.....	48
	Conclusion	51
	References.....	52

Part II Exoplanet Upper Atmospheres and Stellar Interaction: Observations and Modelling

4	Observations of Exoplanet Atmospheres and Surrounding Environments	59
	Luca Fossati, Carole A. Haswell, Jeffrey L. Linsky, and Kristina G. Kislyakova	
4.1	Introduction: Exoplanet Atmospheres.....	59
4.2	The Deepest Observed Layers of Hot Jupiter Atmospheres.....	61
4.2.1	Heat Transport in the Thermosphere	61
4.2.2	The Dayside Emitted Spectrum	61
4.2.3	Clouds, Hazes and Aurorae	62
4.2.4	Alkali Metal Features.....	62
4.2.5	Balmer Lines.....	63
4.3	Transmission Spectroscopy of Hot Jupiter Exospheres	63
4.3.1	Far-UV Observations	63
4.3.2	Near-UV Observations	69
4.3.3	Early Ingresses.....	71
4.3.4	X-Ray Observations of the Transit of HD 189733 b	71
4.4	WASP-12: An Enshrouded Planetary System.....	71
4.5	Star-Planet Interactions	73
	Conclusion	74
	References.....	76

5	Types of Hot Jupiter Atmospheres	81
	Dmitry V. Bisikalo, Pavel V. Kaygorodov, Dmitry E. Ionov, and Valery I. Shematovich	
5.1	Introduction: Exoplanet Gaseous Envelopes	81
5.2	Outflow of the Hot Jupiter Atmosphere Caused by the Gravity of the Host Star	82
5.3	Interaction of Hot Jupiter Atmospheres with Stellar Winds	86
5.4	Classification of Hot Jupiter Envelopes	90
5.5	Shapes of Hot Jupiter Atmospheres as Obtained from 3D Numerical Simulations	95
	Conclusion	101
	References	103
6	Suprathermal Particles in XUV-Heated and Extended Exoplanetary Upper Atmospheres	105
	Valery I. Shematovich, Dmitry V. Bisikalo, and Dmitry E. Ionov	
6.1	Introduction: Short-Wavelength Radiation Effects in Upper Atmospheres	106
6.2	Aeronomy of Suprathermal Atoms in Planetary Upper Atmospheres	106
6.2.1	Hot Planetary Coronae	107
6.2.2	Suprathermal Neutral Particles	108
6.2.3	Kinetic Description of Suprathermal Particles	109
6.2.4	The Stochastic Kinetic Equation for Suprathermal Particles	111
6.2.5	The Analogue Monte Carlo Method of Solving the Stochastic Kinetic Equation	112
6.2.6	Current Progress on Hot Atom Corona Modeling	113
6.3	Suprathermals in the Extended Atmosphere of the Hot Jupiter HD 209458b	114
6.4	Heating Efficiency in Hydrogen-Dominated Upper Exoplanet Atmospheres	117
6.4.1	Photolytic and Electron-Impact Processes in the Upper Atmosphere	117
6.4.2	Kinetic Equation	120
6.4.3	Numerical Model	120
6.4.4	Energy Deposition of the Stellar Soft X-Ray and EUV Radiation	121
6.4.5	Calculations of Heating Efficiency Height Distribution	122
6.5	Suprathermal Fraction of Atomic Hydrogen	125
6.5.1	Molecular Hydrogen Dissociation in the Upper Atmosphere of HD 209458b	125

6.5.2	Kinetics of Suprathermal Hydrogen Atoms	127
6.5.3	Calculation Results	129
	Conclusion	132
	References	133
7	Stellar Driven Evolution of Hydrogen-Dominated Atmospheres from Earth-Like to Super-Earth-Type Exoplanets	137
	Kristina G. Kislyakova, Mats Holmström, Helmut Lammer, and Nikolai V. Erkaev	
7.1	Introduction: Hydrogen-Rich Terrestrial Exoplanets	138
7.2	Thermal Escape	140
7.3	Ion Pick-Up	145
	Conclusion	148
	References	150
8	Interpretations of WASP-12b Near-UV Observations	153
	Aline A. Vidotto, Dmitry V. Bisikalo, Luca Fossati, and Joe Llama	
8.1	Introduction: WASP-12b an Evaporating Hot Jupiter	153
8.1.1	The Bow Shock Model	155
8.2	The Bow Shock Surrounding the Planet's Magnetic Obstacle	156
8.2.1	Radiation Transfer Simulations of the Near-UV Transit	158
8.2.2	Transit Variability	160
8.3	Gas Dynamic Simulation of the Interaction Between WASP-12b and Its Host Star	160
8.3.1	Model Description	161
8.3.2	The Flow Structure Around the Planet	164
8.3.3	Early Ingress in Pure Gas Dynamic Model	165
	Conclusion	166
	References	167
9	The Effects of Close-in Exoplanets on Their Host Stars	169
	Eike W. Guenther and Stephan Geier	
9.1	Introduction: Stellar Activity Triggered by Hot Jupiters	169
9.2	Enhanced Chromospheric Activity and Spot Coverage Caused by Close-in Planets	171
9.2.1	The Ca II Lines	171
9.2.2	The UV-Radiation from the Chromosphere	172
9.2.3	The Corona and the Stellar Wind	173
9.2.4	Magnetic Fields in the Photosphere and Stellar Spots	174
9.2.5	Flares	175
9.2.6	The Solar System	177
9.3	Bow Shocks	177

9.4	Can Planets Affect Stellar Rotation?	178
9.5	The Engulfment of Planets.....	179
	Conclusion	182
	References.....	182

Part III Exoplanet and Astrophysical Magnetic Fields

10	Magnetosphere Environment from Solar System	
	Planets/Moons to Exoplanets	189
	Igor I. Alexeev, Maria S. Grygoryan, Elena S. Belenkaya, Vladimir V. Kalegaev, and Maxim Khodachenko	
10.1	Introduction: Magnetospheres	190
10.2	Magnetospheres of the Earth, Jupiter, and Saturn	190
	10.2.1 Paraboloid Magnetosphere Model: General Issues	191
	10.2.2 Paraboloid Model of Mercury's Magnetosphere	196
	10.2.3 Jupiter's Magnetosphere.....	199
10.3	Paraboloid Model Application to Hot Jupiter Magnetospheres	203
	10.3.1 Magnetodisks Are Key Elements of Hot Jupiter Magnetospheres	203
	Conclusion	207
	References.....	211
11	Detection Methods and Relevance of Exoplanetary	
	Magnetic Fields	213
	Jean-Mathias Grießmeier	
11.1	Introduction: Planetary Magnetic Fields	213
11.2	Effects of Magnetic Fields on Gas Giants.....	214
	11.2.1 Gas Giants: Superflares.....	214
	11.2.2 Gas Giants: Planetary migration	215
	11.2.3 Gas Giants: H_3^+ Emission	216
	11.2.4 Gas Giants: Planetary Mass Loss	217
	11.2.5 Gas Giants: Chromospheric Emission	218
	11.2.6 Gas Giants: Early Transit Ingress and Bow Shock Modelling	219
	11.2.7 Gas Giants: Transit Profile and Ly- α Absorption Modelling	221
	11.2.8 Gas Giants: Radio Emission	221
11.3	Effects of Magnetic Fields on Terrestrial Planets	225
	11.3.1 Terrestrial Planets: Atmospheric Escape	226
	11.3.2 Terrestrial Planets: Protection Against Cosmic Rays	228
	11.3.3 Terrestrial Planets: Comet-Like Exosphere	231
	Conclusion	231
	References.....	232

12	Alfvén Radius: A Key Parameter for Astrophysical Magnetospheres	239
	Elena S. Belenkaya, Maxim L. Khodachenko, and Igor I. Alexeev	
12.1	Introduction: Alfvén Radius and Astrophysical Magnetic Environments	239
12.2	“Non-local Alfvén Radius” in Magnetized Planetary Magnetospheres	240
12.3	Alfvén Radius in the Magnetized Planet Magnetospheres Including Disks	244
12.4	Alfvén Radius in the Magnetospheres of Magnetized Stars	245
12.5	Alfvén Radius in the Magnetospheres of Compact Objects in the Presence of a Strong Magnetic Field	245
	Conclusion	247
	References	248
 Part IV Space and Ground-Based Exoplanet Observation and Characterization Tools		
13	Living with Stars: Future Space-Based Exoplanet Search and Characterization Missions	253
	Malcolm Fridlund, Heike Rauer, and Anders Erikson	
13.1	Introduction and Background	253
13.1.1	What Do We Currently Know About the Physics of Exoplanets?	255
13.2	Current and Near Future Observations from Space	260
13.2.1	The Hubble Space Telescope	261
13.2.2	CoRoT: The First Dedicated Space Mission Related to Exoplanets	262
13.2.3	Kepler	263
13.2.4	Gaia: Bulk Observations	264
13.2.5	The Immediate Future: TESS, CHEOPS and the James Webb Space Telescope	265
13.3	The Next Step (ESA): PLATO 2.0	267
13.4	The Next Step (NASA): WFIRST, Coronagraphs and Occulters	269
13.5	Further Future: Darwin, TPF and New World Observatories	270
	Conclusion	271
	References	272

14 The World Space Observatory–UV Project as a Tool for Exoplanet Science	275
Boris M. Shustov, Mikhail E. Sachkov, Dmitry V. Bisikalo, and Ana-Ines Gómez de Castro	
14.1 Introduction: UV Exoplanet Astronomy After HST	276
14.2 The WSO–UV Mission	276
14.3 WUVS: WSO–UV Spectrographs	278
14.4 Comparison of WSO–UV and HST Spectrograph Efficiency	278
14.5 ISSIS: Imaging and Slitless Spectroscopy Instrument for Surveys	280
14.6 WSO–UV Orbit	282
14.7 WSO–UV Science Management Plan	283
14.8 WSO–UV Status 2014	284
14.9 WSO–UV Ground Segment	285
Conclusion	285
References	287
15 Ground-Based Exoplanet Projects	289
Eike W. Guenther	
15.1 Introduction: Ground-Based Exoplanet Research	289
15.2 Radial Velocity Measurements	290
15.2.1 The Absorption Cell Method	291
15.2.2 The Emission-Line Method	292
15.2.3 Photometric Observations of Transits	296
15.2.4 Spectroscopic Observations of Transits	298
15.3 Direct Imaging and Interferometry	299
15.4 Astrometry, Polarization, Microlensing	302
Conclusion	302
References	303
Index	307

Characterizing Stellar and Exoplanetary Environments

Lammer, H.; Khodachenko, M. (Eds.)

2015, XXI, 310 p. 85 illus., 50 illus. in color., Hardcover

ISBN: 978-3-319-09748-0