

Contents

10	Planetary Atmospheres	337
10.1	Atmospheric Constituents	337
10.2	Atmospheric Structure	340
10.2.1	Pressure Variation with Height	340
10.2.2	Temperature Variation with Height	344
10.3	Circulation in the Atmosphere	349
10.3.1	Centrifugal and Coriolis Forces	349
10.3.2	Physical Effects of the Centrifugal and Coriolis Forces	352
10.3.3	Pressure Gradient Force	354
10.3.4	Friction	355
10.3.5	Geostrophic Balance and Geostrophic Winds	356
10.3.6	Thermal Effects	357
10.3.7	Global Circulation	360
10.4	Atmospheric Effects on the Heat Budget	367
10.4.1	The Earth	367
10.4.2	Mars	371
10.4.3	Venus	374
10.5	Planetary Circulation Effects	377
10.5.1	Circulation and the Coriolis Force	377
10.5.2	Meridional (N-S) Circulation	378
10.5.3	Zonal (E-W) Circulation	380
10.5.4	Other Considerations	385
10.5.5	Chemical Cycles	389
10.5.6	Excess Radiation	394
	Challenges	395
	References	396

11 Planetary Ionospheres and Magnetospheres	399
11.1 Earth: Ionospheric Layers	399
11.1.1 The F Layer	399
11.1.2 The E Layer	403
11.1.3 The D Layer	404
11.1.4 Reflection of Radio Waves	406
11.2 Atmospheric and Ionospheric Chemistry	
on Mars and Venus	407
11.2.1 Neutral Atmosphere of Mars	407
11.2.2 Neutral Atmosphere of Venus	408
11.2.3 Ionosphere of Mars	409
11.2.4 Ionosphere of Venus	410
11.2.5 Atmospheric Escape Mechanisms	411
11.3 Solar Wind	416
11.4 Maxwell's Equations and the Plasma Frequency	417
11.4.1 Maxwell's Equations	417
11.4.2 Application to a Polarized Wave	420
11.5 The Earth's Magnetosphere	423
11.5.1 Forces Acting on Charged Particles	425
11.5.2 \vec{E} Uniform and Time-Independent; $\vec{B} = 0$	427
11.5.3 \vec{B} Uniform and Time-Independent; $\vec{E} = 0$	428
11.5.4 Guiding Center	429
11.5.5 Diamagnetism	430
11.5.6 $\vec{E} \times \vec{B}$ Drift and Field-Aligned Currents	431
11.5.7 $\vec{E} \times \vec{B}$ Drift with Collisions	434
11.5.8 Polarization Drift	435
11.5.9 Gradient and Curvature Drift	437
11.6 Electric Currents in the Ionosphere and Magnetosphere	439
11.6.1 The Ionospheric Dynamo	439
11.6.2 Boundary Current	440
11.6.3 Ring Current	441
11.6.4 Magnetic Storms	448
11.6.5 Magnetospheric Convection	449
11.6.6 The Magnetotail Current Sheet	451
11.6.7 Coupling Between the Magnetosphere and the Ionosphere	452
11.6.8 Magnetospheric Substorms	454
11.7 Magnetospheres of Mercury, Venus, and Mars	458
11.7.1 Mercury	458
11.7.2 Venus	462
11.7.3 Mars	467
Challenges	470
References	472

12 The Giant Planets	475
12.1 Jupiter	478
12.1.1 Visible Phenomena	478
12.1.2 Jovian Atmospheric Structure	483
12.2 Saturn	486
12.3 Uranus	490
12.4 Neptune	492
12.5 Internal Pressures	494
12.6 Excess Radiation	496
12.7 Ionospheres of the Giant Planets	497
12.8 The Jovian Magnetosphere	498
12.8.1 Inner Magnetosphere of Jupiter	500
12.8.2 Middle Magnetosphere of Jupiter	501
12.8.3 Outer Magnetosphere of Jupiter	502
12.8.4 Jovian Aurorae	503
12.8.5 Interaction with Io	503
12.9 Saturn's Magnetosphere	511
12.9.1 Neutral and Ionic Content	512
12.9.2 Magnetospheric Currents	513
12.9.3 Radiation Belts	514
12.9.4 Saturn Kilometric Radiation (SKR)	515
Challenges	516
References	516
13 Satellite and Ring Systems	521
13.1 Satellites	521
13.1.1 The Moons of Mars	528
13.1.2 The Moons of Jupiter	535
13.1.3 The Moons of Saturn	548
13.1.4 Uranian Moons	563
13.1.5 Neptunian Moons	564
13.1.6 Pluto-Charon	567
13.2 Origins of Ring Systems	570
13.3 Ring Structures	572
13.3.1 Jovian Rings	572
13.3.2 Saturnian Rings	575
13.3.3 Uranian Rings	578
13.3.4 Neptunian Rings	581
13.3.5 Nature and Possible Origins of the Ring Structures	582
13.4 Orbital Stability of the Moons	586
13.4.1 Satellite Stability	586
13.4.2 Conjectures about Pluto	587
13.5 Origins of the Moons	590
Challenges	590
References	591

14	Comets and Meteors	597
14.1	Comets in History	597
14.1.1	Early History	597
14.1.2	Tycho Brahe and the Comet of 1577	598
14.1.3	Later Historical Studies	600
14.2	Comet Designations	601
14.3	Cometary Orbits	603
14.4	Typical and Historically Important Comets	609
14.5	Cometary Structure	612
14.6	Cometary Composition	614
14.7	Induced Magnetospheres of Comets	622
14.8	Origins of Comets	625
14.8.1	Formation of the Nucleus	625
14.8.2	Origin of the Present Distribution of Comets	625
14.9	Cometary Demise	628
14.10	Meteor Showers	630
14.11	Individual Meteors	632
14.11.1	Basic Meteor Phenomena and Circumstances	632
14.11.2	Meteor Heating and Incandescence	633
14.12	Micrometeorites	639
14.13	Dust Destinies	640
14.13.1	Radiation Pressure	640
	Challenges	643
	References	643
15	Meteorites, Asteroids and the Age and Origin of the Solar System	647
15.1	Stones from Heaven	647
15.1.1	Categories and Nomenclature of Meteorites	648
15.1.2	Petrographic Categories	650
15.1.3	Meteorite Groupings and Subgroupings	652
15.2	Undifferentiated Meteorites: The Chondrites	657
15.2.1	Defining the Chondrites	657
15.2.2	Carbonaceous Chondrites	659
15.2.3	Ordinary Chondrites	660
15.2.4	Enstatites	660
15.2.5	The R Group	661
15.2.6	Former Members, from the IAB Clan	661
15.2.7	Origins of the Chondrites	661
15.3	Differentiated Silicate-Rich Meteorites	662
15.3.1	The Igneous Clan	663
15.3.2	Other DSR Meteorites	664
15.4	Iron Meteorites	667

15.5	Ages and Origins of Meteorites	669
15.5.1	Radiometric Ages	669
15.5.2	Gas Retention Ages	672
15.5.3	Cosmic Ray Exposure Ages	673
15.5.4	Case Study: The Zagami SNC Basaltic Shergottite	673
15.6	Other Sources of Evidence for Meteoritic Origins	674
15.7	Parent Bodies and the Asteroids	676
15.7.1	The Discovery of Ceres	676
15.7.2	Nomenclature	677
15.7.3	Groups of Asteroids and Families of Orbits	681
15.7.4	Dimensions and Masses of Asteroids	686
15.7.5	Case Study: (4) Vesta	690
15.7.6	Asteroids and Meteorites	696
15.8	Implications for the Origin of the Solar System	701
15.9	The Solar Nebula	701
15.10	The Proto-Planetary Disk	704
	Challenges	706
	References	707
16	Extra-Solar Planetary Systems	713
16.1	Historical Perspective	713
16.2	Methods to Find “Small”-Mass Companions	742
16.2.1	Radial Velocity Variations of the Visible Component	743
16.2.2	Transit Eclipses	747
16.2.3	Astrometric Variations	750
16.2.4	Gravitational Lensing	753
16.2.5	Direct Imaging and Spectroscopy	755
16.2.6	Pulsar Timings	756
16.2.7	Indirect Effects	757
16.3	Definitions of Planets and Brown Dwarfs	758
16.4	Extra-Solar Planets Detected or Awaiting Confirmation	761
16.4.1	HD 209458b	764
16.4.2	The Multi-planet System of υ Andromedae	767
16.4.3	The Multi-planet System of 55 Cancri	767
16.4.4	The Multi-planet System of Kepler 11	768
16.4.5	The Multi-planet System of HD 69830	769
16.4.6	The Multi-planet System of Gliese J 876	770
16.4.7	The ϵ Eridani System	770
16.4.8	The TrES-1 System	771
16.4.9	The WASP-17 System	772

16.4.10	The Closely Packed Planetary System of Kepler 32	774
16.4.11	Approaching Another Milestone in Extrasolar Planet Research: The Search for α Cen Bb	775
16.5	Origins of Brown Dwarfs and Planets	776
	Challenges	781
	References	782
Index	797

Solar System Astrophysics

Planetary Atmospheres and the Outer Solar System

Milone, E.F.; Wilson, W.J.F.

2014, XVIII, 480 p. 188 illus., 27 illus. in color.,

Hardcover

ISBN: 978-1-4614-9089-0