

Contents

1	General Features of the Solar System	1
1.1	Mechanics and Dynamics of the Solar System	5
1.1.1	Newton's Law of Universal Gravitation	5
1.1.2	Kepler's Laws	7
1.1.3	The Titius–Bode ‘Law’	10
1.1.4	Resonances	11
1.1.5	Gravity in a Solid Body: Shape and Tidal Effects	14
1.1.6	The Roche Limit	15
1.1.7	Collisions	17
1.1.8	The N -body Problem	18
1.1.9	Long-Term Evolution of the Solar System	19
1.1.10	Specific Configurations in the Earth–Moon System: Eclipses	20
1.2	Physics of the Solar System	22
1.2.1	Thermal Radiation and Reflected Solar Radiation	23
1.2.2	Planets	26
1.2.3	Satellites	30
1.2.4	Rings	31
1.2.5	Asteroids	32
1.2.6	Comets	33
1.2.7	Trans-Neptunian Objects	35
1.2.8	The Interplanetary Medium	35
2	The Solar System Within the Universe	43
2.1	Distance Scales	43
2.2	Primordial Nucleosynthesis in the Big Bang	48
2.3	Life and Death of the Stars	49
2.4	Stellar Nucleosynthesis	49
2.5	The First Stages of Stellar Formation	51
2.6	The Interstellar Medium	53
3	Methods of Studying the Solar System	59
3.1	The Determination of Geometrical and Physical Parameters	59
3.1.1	Determining Distances	59
3.1.2	Determining Diameters	60

3.1.3	Determining Masses	61
3.1.4	Determining Periods of Rotation	62
3.2	Physical and Chemical Analysis of Gas and Dust Particles	62
3.2.1	Analysis of Radiation by Remote Sensing Spectroscopy	62
3.2.2	Analysis of Radiation as a Function of Phase Angle	68
3.2.3	Analysis of the Thermal Structure of an Atmosphere by the Stellar Occultation Method	68
3.2.4	In-Situ Analysis	68
3.3	The Analysis of Plasma and Magnetic Fields	72
3.3.1	Observations from the Ground	72
3.3.2	Observations from Space	73
4	The Formation of the Solar System	79
4.1	The History of Models of the Solar System's Formation	79
4.1.1	The Copernican Model	79
4.1.2	Different Classes of Models: From the 15th to the 20th Century	80
4.2	The Observations	82
4.3	The Emergence of a 'Standard Model'	88
4.3.1	The Gaseous Protoplanet (or Massive Disk) Model	88
4.3.2	The 'Standard Model'	89
4.3.3	The Chronology of Events	89
4.4	Comparison with Other Systems	102
4.4.1	Stellar Environments	102
4.4.2	Extrasolar Planets	103
5	The Interaction of Solar-System Bodies with the Interplanetary Medium	105
5.1	The Interplanetary Plasma: Solar Wind and Coronal Expansion	106
5.1.1	Coronal Expansion	106
5.1.2	The Large-Scale Structure of the Heliosphere in the Plane of the Ecliptic	110
5.1.3	The Three-dimensional Structure of the Heliosphere	111
5.1.4	Transient Structures in the Solar Wind	114
5.1.5	The Interaction of the Heliosphere with the Interstellar Medium	117
5.2	The Outer Gaseous Envelopes of the Planets: Thermospheres and Ionospheres	120
5.2.1	The Structure of the Neutral Upper Atmosphere	122
5.2.2	The Structure and Dynamics of Ionospheric Layers	130
5.3	Interaction of the Solar Wind with Solar-System Objects	142
5.3.1	The Different Types of Interaction	142
5.3.2	Interaction of the Solar Wind with Non-magnetic Gaseous Envelopes: Case (b)	144

5.3.3	Interaction of the Solar Wind with Magnetized Planets: Case (d)	152
5.3.4	The 'Auroral' Radio Emissions of Planetary Magnetospheres	168
6	The Terrestrial Planets and Their Satellites	183
6.1	Mercury	184
6.1.1	Orbital Parameters and Macroscopic Properties	185
6.1.2	Mercury's Exosphere and Polar Regions	185
6.1.3	The Interior of Mercury and Its Magnetic Field	186
6.1.4	Mercury's Surface	186
6.1.5	Mercury's Magnetosphere	189
6.2	Venus	191
6.2.1	The Observation of Venus	191
6.2.2	Orbital Parameters and Overall Properties	194
6.2.3	The Surface and Interior of Venus	194
6.2.4	The Atmosphere of Venus	199
6.3	The Earth	206
6.3.1	Orbital Characteristics	207
6.3.2	Internal Structure	208
6.3.3	Plate Tectonics	210
6.3.4	The Earth's Magnetic Field	217
6.3.5	The Present-Day Atmosphere	219
6.3.6	The Terrestrial Climate and the Atmospheric Circulation ...	222
6.4	The Moon	225
6.4.1	Telescopic Observation of the Moon	226
6.4.2	Observations from Spacecraft	227
6.4.3	Analysis of Samples in the Laboratory	232
6.4.4	The Origin of the Moon	234
6.4.5	The Earth-Moon System	235
6.5	Mars	237
6.5.1	Observation of Mars	237
6.5.2	Orbital Parameters, Overall Physical Properties and Internal Structure	239
6.5.3	Geological Formations	239
6.5.4	The Composition of the Martian Surface	244
6.5.5	The Atmosphere of Mars	248
6.5.6	Comparative Studies of the Atmospheres of the Terrestrial Planets	254
6.5.7	The Search for Fossil Life on Mars	258
6.6	Phobos and Deimos	259

7	The Asteroids	263
7.1	Orbital Characteristics	264
7.2	The Physical Nature of the Asteroids	268
7.3	The Chemical and Mineralogical Composition of Asteroids	271
7.4	Recent Results from Spaceprobe Observations	275
7.5	The Origin and Evolution of Asteroids	278
7.6	The Interaction Between Asteroids and the Solar Wind	280
8	The Giant Planets	283
8.1	Introduction	283
8.2	The Neutral Atmosphere of the Giant Planets	285
8.2.1	The Thermal Structure	287
8.2.2	Cloud Structure	290
8.2.3	Molecular Abundances	299
8.2.4	The Abundance Ratios of Elements and Isotopes	301
8.2.5	The Upper Atmospheres of the Giant Planets	311
8.3	The Internal Structure of the Giant Planets	318
8.3.1	The Experimental Data	318
8.3.2	Modelling the Internal-Energy State	320
8.4	The Magnetic Fields and Magnetospheres of the Giant Planets	325
8.4.1	Jupiter's Magnetic Field	327
8.4.2	The Structure of Jupiter's Magnetosphere	330
8.4.3	The Dynamics of Jupiter's Magnetosphere	332
8.4.4	The Magnetic Field and Magnetosphere of Saturn	342
8.4.5	The Magnetic Fields of Uranus and Neptune	346
9	Titan	349
9.1	The Neutral Atmosphere of Titan	349
9.1.1	The Chemical Composition of the Atmosphere	349
9.1.2	The D/H Ratio in Titan's Atmosphere	352
9.1.3	Thermal Structure of the Atmosphere	353
9.1.4	Aerosols and Clouds	354
9.2	Titan's Upper Atmosphere	354
9.2.1	Composition and Structure of the Upper Atmosphere	354
9.2.2	Interaction with the Magnetosphere	355
9.2.3	The Aeronomy of Titan and the Formation of Complex Molecules	356
9.3	The Surface and Interior of Titan	358
9.3.1	The Surface of Titan	358
9.3.2	The Interior of Titan	359
9.4	Titan's Interaction with Saturn's Magnetosphere	361

10 Bodies Without Atmospheres in the Outer Solar System	363
10.1 The Satellites of the Giant Planets	363
10.1.1 The Satellites of Jupiter	363
10.1.2 The Satellites of Saturn	375
10.1.3 The Satellites of Uranus	379
10.1.4 The Satellites of Neptune	381
10.2 Pluto and Charon	384
10.2.1 Historical	384
10.2.2 Exploration of the Pluto–Charon System	384
10.2.3 Pluto: Atmosphere and Surface	385
10.2.4 Charon	387
10.2.5 The Origin of the Pluto–Charon Pair	387
10.3 The Rings of the Giant Planets	388
10.3.1 The Formation of Planetary Rings	388
10.3.2 Jupiter’s Rings	390
10.3.3 Saturn’s Rings	392
10.3.4 The Rings of Uranus	395
10.3.5 Neptune’s Rings	395
11 Comets	399
11.1 The Nomenclature of Comets	400
11.2 The Orbits of Comets and the Problem of Their Origin	400
11.3 Measuring the Brightness of Comets	407
11.4 The Physics of Comets	409
11.4.1 The Nucleus	411
11.4.2 The Coma	416
11.4.3 The Cometary Dust	424
11.4.4 Cometary Material and the Interstellar Medium	427
11.5 The Interaction of Comets with the Solar Wind	428
12 New Frontiers	433
12.1 Introduction	433
12.2 The Discovery of Distant Objects	433
12.3 Orbital Characteristics of the Trans-Neptunian Objects	435
12.4 The Centaurs	436
12.5 Physical Properties and Composition	437
13 Interplanetary Dust, Micrometeorites and Meteorites	443
13.1 Introduction	443
13.2 The Mass Distribution	444
13.3 The Spatial Distribution of Interplanetary Material	446
13.4 Meteorites	449
13.4.1 Classification	450
13.4.2 The Origin of Meteorites	451
13.4.3 Martian Meteorites	452

13.4.4	The Chemical Composition of Meteorites	453
13.4.5	The Isotopic Composition of Meteorites	454
13.4.6	Isotopic Anomalies and the Origin of the Solar System	458
13.5	Collecting Cometary Material	461
14	New Planetary Systems	463
14.1	Introduction	463
14.2	The Limits of the Planetary Domain	463
14.3	Circumstellar Disks	464
14.3.1	Beta Pictoris	464
14.3.2	Other Circumstellar Disks	465
14.4	Extrasolar Planets	465
14.4.1	Two Stages: 1992 and 1995	465
14.4.2	Search Methods	466
14.4.3	The Range of Extrasolar Planets	471
14.5	Knowledge Acquired and Remaining Questions	474
14.5.1	The Outcome of the Observations	474
14.5.2	Theoretical Questions Posed by the Initial Discoveries	478
14.5.3	Some Observational Projects	481
14.6	Conclusions	484
15	The Search for Life in the Universe	487
15.1	What Is Life?	488
15.2	The Laboratory Experiments	489
15.3	The Search for Life in the Solar System	489
15.3.1	The Analysis of Lunar Samples	490
15.3.2	Meteorites, Micrometeorites, and Comets	490
15.3.3	Mars	490
15.3.4	The Giant Planets	492
15.3.5	Europa	492
15.3.6	Titan	493
15.4	Possibilities for Life in the Universe	493
15.4.1	What Is the Likelihood of Life Existing in the Universe? . .	494
15.4.2	The Search for Extraterrestrial Life	494
	References	497
	Index	503

The Solar System

Encrenaz, T.; Bibring, J.-P.; Blanc, M.; Barucci, M.-A.;
Roques, F.; Zarka, P.

2004, XII, 514 p., Hardcover

ISBN: 978-3-540-00241-3