

Index

- D'' region, 263
- $I/\mathcal{F}$, 59
- β -effect, 109
- γ -ray fluorescence, 571
- ^3He , 386
- ν_6 resonance, 581
- 'a'a, 168*f*, 168
- ablation, 184
- absorption, 67
- absorption coefficient, 67, 71
- absorption line, 85
- accretion zone, 534
- achondrites, 337, 339, 358
 - eucrite, 339
 - HED, 358
- acid rain, 194
- activation energy, 127
- active region, 283
- active sector, 317, 319
- Adams–Williams equation, 261, 281
- adaptive optics (AO), 104, 194, 494, 568*f*, 568–569
- adiabatic invariants
 - first invariant, 297
 - second invariant, 297–298
 - third invariant, 298
- adiabatic lapse rate, 63–64, 80–81, 149
 - dry, 64, 80
 - giant planets, 77
 - superadiabatic, 64, 70, 111
 - wet, 101–102
- Adrastea, 225, 227*f*, 454*f*, 484
- advection, 61
- advective derivative, 108
- aeolian processes, 173
- aerodynamic drag, 49, 55, 102, 347–348, 416
- aerogel, 432*f*, 432
- AGB star (asymptotic giant branch), 527
- agregates, 528
- airglow, 135
- Airy hypothesis, 252–253, 280
- Aitken basin, 266
- albedo
 - Bond albedo, 58, 77, 144
 - geometric albedo, 59
 - giant planets, 77
 - monochromatic albedo, 58
 - terrestrial panets, 77–78
- albite, 162, 239
- Aleutan islands, 167
- Alfvén velocity; *see* velocity
- Alfvén waves, 291, 306
- ALH84001, 342
- allotropes, 217
- α decay, 352, 365
- Amalthea, 227*f*, 455, 484
- amorphous ice, 412, 438
- Ampere's law, 290
- amphibole, 154
- andesite, 156*f*
- angle of repose, 163
- angular momentum, 521
- anhydrous rock, 550
- anion, 153
- anomalous cosmic rays, 311*f*, 312
- anorthite, 162, 197
- anorthosite, 197
- ansa, 459
- antapex, 189
- Antarctica, 214
- anticyclone, 111*f*, 112
- antipode, 183, 197, 316
- apex, 189
- Apollo program, 16
- Apollo spacecraft, 95, 185, 196–197, 267*f*, 316, 341
- apparition, 407
- aqueous alteration, 401
- arachnoid, 201, 202*f*
- Archimedean spiral, 287*f*
- Archimedes principle, 251

- Ariel, 235, 236*f*
- Aristotle, 506
- ash, 158
- asteroid belt, 368, 581
- asteroids, 13, 33*f*, 33, 34*f*, 50, 158, 189, 337, 366–404, 410, 512–513, 548, 551
 - Amor asteroids, 369
 - Apohele asteroids, 369
 - Apollo asteroids, 369
 - Aten asteroids, 369
- binaries, 387
 - satellites, 4
- collisions, 385
- composition, 378–382
- density, 389–391
 - Table 9.5, 392
- differentiation, 513, 553
- dynamics, 30
- families, 385–387, 386*f*
 - Baptista, 386*f*, 396
 - Eos, 394*f*
 - Flora, 344
 - Hirayama, 386
 - Karin, 386*f*
 - Koronis, 394*f*, 396
 - Themis, 394*f*, 411
 - Veritas, 386*f*, 386
- formation, 542–543, 547
- IMCs, 369
- individual
 - 1 Ceres, 366, 378, 379*f*, 385, 391
 - 2 Pallas, 366, 391
 - 4 Vesta, 343, 358, 366, 379*f*, 380–381, 391, 401, 592, 592*f*
 - 8 Flora, 379*f*
 - 10 Hygiea, 366
 - 11 Parthenope, 391
 - 15 Eunomia, 379*f*
 - 16 Psyche, 379*f*, 401
 - 19 Thetis, 391
 - 21 Lutetia, 591
 - 44 Nysa, 379*f*
 - 45 Eugenia, 388
 - 87 Sylvia, 367, 390*f*
 - 90 Antiope, 389*f*
 - 93 Minerva, 388
 - 113 Amalthea, 379*f*
 - 121 Hermione, 389*f*
 - 197 Arete, 391
 - 216 Kleopatra, 376, 390*f*
 - 243 Ida, 374, 388*f*, 388, 391, 395–396
 - 253 Mathilde, 374, 391, 395, 396*f*, 397
 - 279 Thule, 33
 - 324 Bamberga, 572*f*
 - 349 Dembowska, 379*f*, 380–381
 - 354 Eleonora, 379*f*
 - 433 Eros, 195, 381, 391, 395, 398*f*, 397–398
 - 446 Aetarnitas, 379*f*
 - 624 Hektor, 370
 - 944 Hidalgo, 372
 - 951 Gaspra, 374, 395–396, 396*f*
 - 1620 Geographos, 375, 378*f*
 - 1862 Apollo, 369, 380–381
 - 1949 Wilson–Harrington, 370
 - 1979 VA, 370
 - 2000 WL₁₀₇, 394
 - 2002 AA₂₉, 371
 - 2060 Chiron, 372, 410*f*, 410
 - 2867 Steins, 398–399, 399*f*
 - 3753 Cruithne, 371
 - 4179 Toutatis, 375
 - 5261 Eureka, 27
 - 6489 Golevka, 47, 375*f*
 - 7968 Elst Pizarro, 411
 - 9969 Braille, 381, 395
 - 118401 Linear, 411
 - 25143 Itokawa, 195, 374, 391, 395, 398, 399*f*
 - Dactyl, 374, 388*f*, 396
 - Hilda asteroids, 33, 368
 - P/2005 U1 (Read), 411
- interior, 256
- lightcurves, 375
- magnetic field, 283, 396
- modeling, 374n[3]
- near-Earth (NEA, NEO), 344, 366, 369–370, 375, 377, 378*f*, 384, 571
- orbital elements: Table 9.1, 367
- orbits, 368–373
- origin, 400–402
- phase function, 377*f*
- radar observations, 375–377, 569–571
- radio spectra, 377
- regolith, 376
- rotation, 391–394, 393*f*, 512
- rubble pile, 387
- size distribution, 383–385
- spatial distribution, 381
- taxonomy, 379–382
- Trojan asteroids, 27, 33, 369*f*, 370, 375, 380–381, 479, 543
- types
 - A type, 379*f*, 380
 - C type, 379*f*, 379–381, 382*f*, 396*f*, 401
 - D type, 380–381, 401
 - E type, 379*f*, 380–381, 382*f*, 401
 - K type, 380
 - M type, 379*f*, 380–381, 382*f*, 401
 - P type, 380–381, 382*f*, 401
 - Q type, 380–381
 - R type, 379*f*, 380–381
 - S type, 379*f*, 380–381, 382*f*, 388*f*, 396*f*, 396

- T type, 380
- U type, 381
- V type, 379*f*, 380–381, 592
- W type, 380, 401
- X type, 380
- asthenosphere, 152, 251, 262
- astrometry, 493–494
- Atlas, 233
- atmosphere, 76–151, *see individual bodies*
 - baroclinic, 111
 - barotropic, 111
 - composition, 15–16
 - formation, 536–537
 - general, 76–151
 - impact, 184–185
 - oxidizing, 143
 - radiative equilibrium, 68–69
 - radiative transfer, 67–68
 - reducing, 143
 - star, 359
 - origins, 143–144, 147
- atmospheric blowoff, 142
- atmospheric tides, 44
- atomic structure, 65–66
- aurora, 15, 135, 312, 319
- auroral zone, 80, 135
- azimuthal asymmetry, 459
- ballistic trajectory, 191
- ballistic transport, 483
- Balmer series, 66
- barometric height distribution, 139
- basalt, 155, 156*f*, 157, 246, 262
- basic, 155
- Beagle Rupus, 198*f*
- Beer’s law, 67
- Ben Reuven, A., 87
- bending waves, 33, 464, 471, 471*f*, 472–474, 472*f*, 473*f*
- β decay, 352, 355, 365, 516
- β Pictoris, 520
- beta-meteoroids, 395
- Biermann, L., 283
- big bang, 514
- binary collision parameter, 139
- binary exchange reactions, 545
- binary melt, 161
- binary stars, 518
- bipolar outflow, 519
- bipolar wind, 523
- Birkeland current, 135, 138
- black hole, 516
- blackbody, 57, 58*f*, 71
- blackbody radiation, 57–58, 58*f*, 78
- blanketing effect, 536
- blue shift, 86
- body waves, 258
- Bohr radius, 65
- Bohr theory, 65
- bolide, 175
- Boltzmann’s equation, 66, 68
- bomb, 158
- Bouguer anomaly, 252–253, 265
- Bouguer correction, 252
- bounce motion, 297*f*
- bow shock, 292–293, 309
- Bowen’s reaction series, 163*f*, 163
- Bowen, N.L., 162
- Brackett series, 66
- Brahe, T., 405
- breccia, 158–159, 183, 341
 - monomict, 159
 - polymict, 159
- Brewster angle, 72
- brown dwarf, 496, 520
- brown dwarf desert, 504, 538
- Brunt–Väisälä frequency, 112, 115
- bulk composition, 16
- bulk modulus, 259, 281
- buoyancy frequency, 112
- Busse, F.J., 120
- butterfly diagram, 284*f*
- CAI, 350, 355, 359–360, 362, 401, 523
- calcite, 158
- caldera, 170, 171*f*
- Callisto, 15, 187, 216, 217*f*, 388, 544
 - atmosphere, 96
 - craters, 182–183
 - interior, 272
 - magnetic field, 325
 - moment of inertia ratio, 250
 - surface, 223–225, 226*f*
 - Valhalla structure, 182
- Caloris basin, 43, 197, 198*f*
- Calypso, 233
- CAPE, 112
- carbonaceous chondrite, 397
- carbonates, 154, 507
- Cassini spacecraft, 94*f*, 97, 123, 169, 194, 230, 231*f*, 395, 448, 450*f*, 474, 583
 - MIMI, 327
- Cassini, G.D., 122
- Cassini, Giovanni, 457
- catalytic reactions, 128
- catastrophic disruption, 184
- cation, 153
- centaurs, 366, 369, 372, 401, 410
- central flash, 14, 567
- central peak, 181
- central pit, 182

- centrifugal force, 24, 110, 112, 248, 300
 centrifugal interchange, 304, 326
 CFHT (Canada-France-Hawaii Telescope), 388
 C_2H_2 (acetylene), 130
 C_2H_4 (ethylene), 130
 C_2H_6 (ethane), 130
 chaos, 30–31, 31*f*, 33*f*, 33–35, 368, 401
 chaos terrain, 222–223
 Chapman reactions, 127
 charge exchange, 141
 Charon, 5, 11, 383, 399–400, 545, 593
 Pluto–Charon system, 27, 43, 545
 C_2H_3CN (ethylcyanide), 130
 chemical potential, 160
 chert, 156*f*
 Chicxulub crater, 193*f*, 193
 CHON particles, *see* comets, composition
 chondrites, 337–338, 350–352, 359*f*,
 359–527
 carbonaceous, 338
 heat flow, 254
 enstatite, 338
 ordinary, 338
 chondrules, 338, 346*f*, 350, 359–360, 362,
 401, 523, 528, 548
 chromophore, 123
 cinder cone, 169
 circumplanetary nebula, 526
 circumstellar disk, 519–520
 clathrate, 155
 Clausius–Clapeyron equation, 102, 116
 Clementine spacecraft, 169*f*, 196,
 265, 566*f*
 climate, evolution, 144–147
 closure temperature, 352
 clouds, 76, 78, 100–106
 aqueous solution cloud, 105
 CH_4 (methane), 106
 H_2S (hydrogen sulfide), 106
 H_2SO_4 (sulfuric acid), 103
 NH_3 (ammonia), 106
 NH_4SH (ammonium hydrogensulfide), 105
 C_2N_2 (cyanogen), 130
 CNO cycle, 515
 CO_2 cycle, 507
 coherent-backscatter effect, 376, 565
 cold plasma, 305
 cold trap, 100
 collisional broadening, 86
 collisional excitation, 423
 collisional radius, 414
 collisionopause, 434
 color temperature, 417
 cometopause, 434
 comets, 4, 11–13, 45, 47, 292, 405–447
 albedo, 435
 alkalies, 429
 anti-tail, 420*f*
 Bond albedo, 413, 416–417, 445
 bow shock, 434
 brightness, 412
 Chiron-type, 411
 coma, 405, 411, 433
 brightness, 412
 formation, 411–415
 comet showers, 409
 composition, 421–433
 carbon, 426, 443
 CH_4 (methane), 427
 CH_3OH (methanol), 427
 CHON particles, 428, 438
 CO (carbon monoxide), 427
 CO_2 (carbon dioxide), 427
 D/H ratio, 430
 dirty snowball, 440
 dust, 431
 HCN (hydrogen cyanide), 428
 H_2CO (formaldehyde), 427
 hydrogen, 425
 isotope ratios, 429, 443
 molecular hydrogen, 425
 N_2 (nitrogen), 428
 NH_3 (ammonia), 428
 nitrogen, 428
 noble gases, 430
 OH (hydroxyl), 425
 ortho:para ratios, 429
 oxygen, 425
 sodium, 429
 sulfur, 429
 dust crust, 416, 438
 dust jets, 418
 dust tail, 45, 418
 dynamically new, 407, 438
 ecliptic comets, 411
 Encke-type, 411
 formation, 543
 free molecular flow, 415
 gas production rate, 413, 423
 Halley family, 411
 hydrogen coma, 415, 425*f*
 individual
 1P/Halley, 405, 414*f*, 414, 417, 426, 427*f*, 428–430, 434,
 437, 440, 445–446
 2P/Encke, 370, 411
 3D/Biela, 439
 8P/Tuttle, 417
 9P/Tempel 1, 412, 431*f*, 431, 441, 442*f*
 17P/Holmes, 439
 19P/Borrelly, 440, 441*f*

- 67P/Churyumov–Gerasimenko, 425, 595
- 73P/Schwassmann–Wachmann 1, 412, 439
- 73P/Schwassmann–Wachmann 3, 439, 440*f*
- 81P/Wild 2, 438, 441*f*, 441
- 95P/Chiron, 373, *see* asteroids, 411
- 103P/Hartley 2, 424
- 107P/Wilson–Harrington, 370
- 133P/Elst Pizarro, 411
- 176P/Linear, 411
- C/Arend–Roland (C/1957 III), 419
- C/Austin, 422*f*
- C/Cernis, 412
- C/Hale–Bopp (C/1995 O1), 406*f*, 412, 416*f*, 417, 419, 420*f*, 422*f*, 425, 428*f*, 428, 429*f*, 430, 431*f*
- C/Hyakutake (C/1996 B2), 417, 428–430, 435, 436*f*
- C/Ikeya (C/1963 A1), 430
- C/Ikeya–Seki (1965 VIII), 429
- C/IRAS–Araki–Alcock (C/1983 VII), 417, 418*f*, 425, 428–429
- C/Kohoutek (C/1973 XII), 419, 426*f*
- C/McNaught (C/2006 P1), 419
- C/Shoemaker, 412
- C/Tabur (C/1996 Q1), 417
- C/West (C/1976 VI), 406*f*, 420*f*, 425*f*, 425, 439*f*, 439
- D/Shoemaker–Levy 9, 129, 175, 190*f*, 190–193, 192*f*, 239, 261, 320, 322*f*, 388, 439–440, 484
- P/2005 U1 (Read), 411
- P/2008 R1 (Garradd), 411
- interstellar, 444
- ion tail, 45, 283, 433, 435
- ionization, 415
- irradiation mantle, 438
- Jupiter family, 411, 513
- linear polarization, 417
- long-period, 407
- magnetosphere, 283, 433–435
- main belt comets, 411
- metals, 429
- neck-line structure, 419
- nomenclature, 406
- nucleus, 405, 408, 435
- origin, 443–444
- parent molecules, 406
- photodissociation, 415
- radar, 417
- rotation, 437
- shape, 411, 437
- short-period, 407
- size, 411, 435, 437
- size distribution, 436
- sodium tail, 429*f*
- spectra, 416
- splitting, 438–439
- streamers, 418, 420*f*
- striae, 418, 420*f*
- Sun-grazing, 429, 440, 441*f*
- tail
 - formation, 411
- talp model, 442
- temperature, 70
- terminal velocity, 414
- thermal expansion, 414
- X-rays, 435
- compact objects, 490
- compressional waves, 306
- condensation
 - heterogeneous, 102
 - homogeneous, 102
- condensation flows, 107
- conduction, 61–63, 80, 256–257
- conglomerate, 156*f*, 158
- conjunction
 - inferior, superior, 570n[1]
- conservation
 - energy, 289
 - mass, 289
 - momentum, 289
- constituent relations, 242–247
- continent, 165, 251, 263
- continental drift, 165*f*, 165, 262
- convection, 61, 63, 80, 111, 257, 264
 - free, 111
 - stagnant lid, 269
- Convective Available Potential Energy (CAPE), 112
- Cordelia, 235, 478
- core nucleated accretion, 538–539
- core–mantle boundary, 261–263
- core-instability hypothesis, 540
- Coriolis effect, 107*f*, 109, 112, 116, 121, 191, 332
- Coriolis parameter, 109
- corona, 135, 141, 201, 283, 317
- coronal hole, 284
- coronal mass ejection (CME), 285*f*, 286
- coronal streamer, 285*f*
- corpuscular drag, 45, 48*f*, 48, 387
- corundum, 525
- cosmic rays, 352, 356, 514n[1], 527
 - exposure age, 357
- cosmic spherules, 346*f*, 347
- Coulomb barrier, 515–516
- Coulomb pressure, 491
- coupling, magnetosphere–ionosphere, 319–320
- covalent bond, 153
- crater, 183, 204*f*, 514
 - chains, 183, 388
 - collapse, 181–183
 - compression stage, 177–178

- crater (*cont.*)
 - contact stage, 177–178
 - cratering rate, 185–189
 - dating, 189
 - ejection stage, 178–181
 - excavation stage, 178–181
 - formation, 177–183
 - jetting, 178
 - modification, 181–183
 - morphology, 175–176
 - complex, 176*f*, 176
 - microcrater, 175*f*, 175
 - multiring, 176
 - simple, 175, 176*f*
 - multiring basin, 182
 - ray, 179, 180*f*, 183
 - removal, 187–188
 - secondary, 179, 183
 - transient, 179
- Crater Lake, 170
- craton, 263
- creep, 173
- creeping motion, 164
- Crisium basin, 315
- critical argument, 33
- critical frequency, 308
- critical point, 105, 245
- crust, 78, 183, 239, 251
- crustal magnetic field, 314
- cryosphere, 81, 117
- cryovolcanism, 225, 228
- Cupid, 235
- Curie point, 15, 265, 315, 332
- current
 - Birkeland current, 310, 311, 320*f*
 - Chapman–Ferraro current, 310
 - field aligned current, 300
 - neutral sheet, 310
 - tail current, 310
- current sheet, 294, 309–310
 - heliospheric, 287
- curve of growth, 85
- cycloidal ridges, 222
- cyclone, 111*f*, 112
- cyclostrophic balance, 109–110, 111*f*
- cyclotron frequency, 297
- cyclotron motion, 297*f*
- cyclotron radiation, 306–307, 307*f*
- Daphnis, 457, 463, 470*f*, 477*f*, 477–478
- Dawn spacecraft, 395
- dawn-to-dusk electric field, 301
- dayglow, 135
- dead zone, 524
- Debye length, 289
- Debye shielding length, 480
- Deep Impact mission, 195, 421, 431, 441, 442*f*
- Deep Space 1 mission, 440, 441*f*
- deflation, 173
- degeneracy, 66
- degenerate matter, 490
- Deimos, 53, 215–216, 374, 545
- Democritus, 506
- dendritic pattern, 172, 209*f*
- density wakes, 459
- density waves, 12, 33, 464, 471, 472*f*, 473–474, 474*f*, 475*f*, 476, 487, 523, 534
- density, uncompressed, 241*n*[1]
- depletion layer, 292
- deposition, 100
- detachment
 - collisional, 132
 - photodetachment, 132
- D/H ratio, 430*f*
- diamond, 153*f*, 153, 160
- diamond anvil press, 243*f*, 243, 246
- diapir, 222–223, 230, 273
- differentiation, 162, 255, 337, 400, 513, 535–536, 553
- diffraction, 496, 568
- diffuse transmission, 459*f*
- diffusion
 - eddy diffusion, 139–140
 - molecular, 138–139
 - turbulent, 139
- diffusion equation, 68
 - magnetic, 291
 - radiative, 69
- diffusion of particles, 304
- Dione, 27, 33, 97, 231, 232*f*
- disequilibrium chemistry, 527
- disk evolution, viscosity, 523–524
- dispersion curves, 260
- dispersion relation, 305
- dissociation, 141
- disturbing function, 30, 34, 408
- doldrums, 115
- dolomite, 158
- domes, 169, 204*f*, 223
- Doppler broadening, 86, 148, 377, 417, 571
- Doppler shift, 12–13, 45–46, 84–86, 493
- Doppler width, 86
- Drake, F., 507
- drift motion, 134, 297*f*, 298–300, 299*f*, 302*f*, 309*f*
- drift shell, 299
 - splitting, 310
- drift velocity, *see* velocity
- ductile, 164
- dune, 173, 174*f*, 203
- dunite, 157, 358

Index

- duricrust, 174, 210
- dust, 78, 83, 158, 394–395, 482, 524
- dust bands, 386*f*, 394*f*, 394
- dust stream, 395
- dust trail, 416
- dwarf planet
 - IAU definition, 366
- dynamical friction, 531
- E ring, 325
- early bombardment era, 185
- Earth, 4–5, 11, 36*f*, 56, 157, 164, 165*f*, 165, 171*f*, 174, 194, 196*f*, 342, 357, 394, 508*f*, 543*f*, 545
 - adiabatic lapse rate, 149
 - AKR, 313
 - atmosphere, 16, 64, 83
 - basic parameters, 77
 - CO₂ (carbon dioxide), 81, 145
 - composition, 88–93
 - eddy diffusion, 140
 - NO (nitric oxide), 81
 - O₃ (ozone), 81
 - oxygen, 81
 - thermal structure, 79*f*, 80
 - aurora, 135, 136*f*
 - bow shock, 293
 - central pressure, 242
 - climate, 116
 - climate evolution, 145–146, 147*f*
 - clouds, 102–103, 103*f*
 - core, 152, 247, 264, 281
 - craters, 182
 - crust, 153
 - Earth–Moon system, 27, 53
 - eddies, 112
 - eddy diffusion, 139
 - general circulation model (GCM), 116
 - geoid, 253
 - geophysical data: Table 1.2, 6
 - global warming, 116
 - gravitational moments, 250
 - gravity field, 251
 - heat flow, 254
 - hydrodynamic escape, 142
 - impact craters, double, 388
 - interior, 241–242, 246, 258, 261–265, 262*f*
 - internal heat, 254, 258
 - ionosphere, 131*f*, 131–132, 135
 - D layer, 132
 - E layer, 131
 - F₂ layer, 131
 - jet stream, 109
 - life, 507
 - lightning, 114
 - magnetic field, 15, 264–265, 281, 294
 - generation, 333
 - parameters, 294
 - reversals, 332–333
 - magnetosphere, 283, 292, 293*f*, 309–313
 - drift motion, 302
 - plasma, 296, 310–312
 - storms, 312–313
 - magnetospheric plasma parameters, 296
 - mantle, 40, 152, 168, 253, 256, 262–264, 507
 - obliquity, 41*f*
 - orbit, 24, 35
 - orbital elements, 5
 - oxygen, 138
 - oxygen chemistry, 127–129
 - oxygen compounds, 128*f*
 - polar-night jet, 116
 - radio emission, 313
 - radio signals, 507
 - rocks, 158, 512
 - satellites
 - orbital data: Table 1.4, 8
 - physical data: Table 1.5, 10
 - seismology, 261
 - surface, 152, 171–174, 174*f*, 184, 186*f*, 203
 - tectonics, 167
 - temperature, 14, 62, 70
 - thermal spectrum, 91*f*
 - tides, 39–41, 43, 53–54
 - trade winds, 109, 115–116
 - troposphere, 101
 - uncompressed density, 242
 - volcanism, 167, 169
 - winds, 106, 107*f*, 107, 115–116
- earthquakes, 39, 164, 166, 258
- eccentricity
 - forced, 9
 - generalized, 25
- eclipse, 495
- ecliptic, 11, 24
- eclogite, 246
- eddies, 112
 - baroclinic, 112
- Edgeworth, K.E., 371
- Edgeworth–Kuiper belt, *see* Kuiper belt objects
- effective gravity, 49, 248, 529
- effusion rate, 168
- Einstein coefficients, 64, 66–67, 423
- Einstein ring, 495
- Einstein, A., 52, 55, 495
- ejecta, 174, 482
- ejecta blanket, 179, 181, 183, 536
- ejecta curtain, 179*f*, 179
- El Niño, 116
- elasticity, 164
- electric currents, 134–135

- electric field, 141, 300–301
 - convection, 300–302
 - corotational, 300
- electric field drift, 300
- electrical skin depth, 71
- electromagnetic induction, 401
- electromagnetic induction heating, 358, 542
- electromagnetic radiation
 - energy, 64
 - momentum, 64
- electromagnetic spectrum, 57*f*
- electron degeneracy pressure, 18
- elements
 - chalcophile, 338
 - cosmic abundances, 340
 - deuterium, 514
 - lithophile, 338
 - siderophile, 337
- emission
 - spontaneous, 66
 - stimulated, 66
- emission coefficient, 67
- emission line, 85
- emissivity, 60
- Enceladus, 4, 15, 33, 97, 167, 169, 231*f*, 256, 273, 325, 487
 - atmosphere, 94
 - E ring, 464, 479
 - surface, 152, 229–230
- Encke gap, 474, 477*f*
- endogenic process, 163
- endothermic reactions, 159
- energetic neutral atom (ENA), 292
- energy
 - conservation of, 63
 - transport, 60–64, 80
- energy density, 65
- energy flux, 289
- energy transitions, 65
- enstatite, 162*f*
- enthalpy, 159, 160*f*
- entropy, 159
- epicenter, 260
- epicyclic frequency, 38–39
- Epimetheus, 29, 33, 233, 469
- Epstein drag, 49, 528
- equation of continuity, 108
- equation of state, 63, 247
- equipotential surface, 248–249
- equivalent width, 85, 148
- Eris, 4, 543, 593
- eruption rate, 168
- escape
 - atmospheric, 140–142
 - hydrodynamic, 142
 - Jeans, 140–142
 - nonthermal, 141–142
 - thermal, 140–141
- escape parameter, 141
- escape velocity, 546*f*
- Euler’s equations, 108, 393
- Europa, 15, 216, 217*f*
 - atmosphere, 96
 - craters, 185
 - interior, 271
 - magnetic field, 325
 - moment of inertia ratio, 250
 - resonance, 32, 44
 - rotation, 11
 - surface, 152, 169, 172, 221–223, 223*f*, 224*f*
 - tides, 256
- eutectic behavior, 161, 247
- EUVE satellite, 435
- evaporite, 156*f*, 158
- exobase, 78, 140, 414
- exogenic process, 163
- exoplanets
 - individual
 - ν Andromedae, 503, 504*f*
 - Barnard’s star, 498
 - CoRoT-7 b, 501, 603*f*
 - GJ 1214 b, 603*f*
 - GJ 3470 b, 603*f*
 - Gliese 436 b, 501, 511
 - Gliese 876, 503, 505
 - Gliese 1214 b, 501
 - HAT-P-6, 604*f*
 - HAT-P-11 b, 501
 - HAT-P-26 b, 603*f*
 - HAT-P-30, 604*f*
 - HD 80606 b, 511
 - HD 97658 b, 603*f*
 - HD 149026 b, 501, 503*f*, 505, 538
 - HD 189733 b, 501*f*, 501, 502, 502*f*
 - HD 209458 b, 499, 500*f*, 501–502
 - Kepler-4 b, 501
 - Kepler-11, 599–600
 - Kepler-36 b, 602
 - Kepler-78 b, 600
 - V391 Pegasi b, 503, 510
 - 51 Pegasi b, 499*f*, 499
 - 55 Cnc e, 603*f*
 - nomenclature, 499
- exosphere, 78, 140
- exothermic reactions, 159
- Explorer 1, 311
- extrasolar planets, 489–512, 520, 547
- Far-UV Spectroscopic Explorer FUSE, 425, 428
- Faraday’s law, 290

- fault, 164, 165*f*
- feldspar, 154, 525
 - orthoclase, 154
 - plagioclase, 154, 162
- felsic, 155
- field line curvature drift, 300
- field reversal, 333
- fire fountains, 169
- fireball, 178, 185, 190
- fission, 353, 365
- fission tracks, 358
- fluorescence, 423
- fluorescence spectroscopy, 571
- fluorine, 128
- flux, 58
- flux density, 57, 65
- flux tube, 317
- flux tube interchange, 326
- forbidden lines, 425
- forced eccentricities, 33
- formation
 - giant planets, 537–540
 - Solar System, 18–19, 512–553
 - stars, 517–519
 - terrestrial planets, 534
- forsterite, 162*f*
- fossil records, 193
- Fourier heat law, 256
- Fourier synthesis, 569
- fractal aggregates, 529
- fractional crystallization, 162
- fractionation, 348–350
- fragmentation, 518, 531
- Frail, D., 498
- Fraunhofer line spectrum, 84*f*
- Fraunhofer lines, 84, 424, 426
- free oscillations, 260–261, 261*f*
- free precession, 251
- free-air correction, 252, 265
- free-air gravity anomaly, 252
- free-fall time, 518, 521, 550
- Fresnel coefficient, 71–72, 75, 570
- Fresnel limb darkening, 72
- frozen-in magnetic field, 291
- FU Orionis stars, 519
- fumarole, 169
- fusion, *see* nuclear fusion
- FWHM, 568
- g-factor, 423–424
- gabbro, 156*f*, 157
- galactic tide, 444
- Galatea, 468*f*, 479
- galaxy (Milky Way), 47, 349, 512
- Galilean satellites, 186*f*, 513, 544
 - interior, 272*f*
 - temperature, 70
- Galileo Galilei, 216, 448
- Galileo probe, 98
- Galileo spacecraft, 80, 93*f*, 96, 98, 106, 121–122, 137, 190, 194, 196*f*, 218, 271–273, 319, 325, 326*f*, 374, 388*f*, 388, 395–396, 448, 454*f*, 455, 537
- Ganymede, 4, 130, 216, 217*f*, 388, 544
 - atmosphere, 96
 - craters, 182–183
 - gravity anomaly, 272
 - interior, 272
 - magnetic field, 15, 325
 - moment of inertia ratio, 250
 - radio emission, 308, 326*f*
 - resonance, 32
 - surface, 188*f*, 223–225, 227*f*
 - tides, 256
- gardening, 187
- gas drag, 48–49, 534, 543–544
- gas instabilities, 538
- gas production rate, 412
- gas retention age, 352
- Gauss coefficients, 295, 334
- Gaussian distribution, 140
- gegenschein, 394
- GEMS, 352
- general relativity, 36*f*, 52, 495, 510
- Genesis mission, 430
- geoid, 163, 248
- geoid height anomaly, 253
- geopotential, 110
- geostrophic balance, 109–110, 110*f*, 121
- geyser, 4, 78, 169, 237*f*, 238
- giant gaseous protoplanets, 538
- giant planets, *see* Jupiter, Saturn, Uranus, Neptune
 - eddy diffusion, 140
 - gas giants, 274
 - ice giants, 274
 - interior, 274–278
- Gibbs free energy, 159–161, 160*f*, 243
- Giotto spacecraft, 155, 414*f*, 414, 421, 428, 430–431, 434, 440
- gneiss, 156*f*
- Goldstone antenna, 378*f*
- GPS (global positioning system), 165
- graben, 165*f*, 165, 167
- gradation, 171
- gradient **B** drift, 299, 302
- gram-mole, 61n[2]
- granite, 155
- graphite, 153*f*, 153, 160
- gravitational collapse, 518–519, 521–522, 550
- gravitational enhancement factor, 532
- gravitational field drift, 300
- gravitational focusing, 189, 534

- gravitational instability, 523, 550
- gravitational moment, 37, 248–251, 275
- gravitational potential, 26, 247–248
- gravitational torque, 534
- gravity, 163
 - effective, 108
- gravity assists, 26
- gravity field, 12, 16, 241, 247–254, 275
- gravity map, 253
- Great Red Spot, *see* Jupiter
- greenhouse effect, 14, 69–70, 80–81, 101, 145, 507, 536, 582
 - anti-greenhouse, 70
 - moist, 147
 - runaway, 147
 - solid-state, 70
- Greenstein effect, 424–426
- group velocity, 305
- guiding center, 297–298
- gypsum, 156*f*, 158
- gyro frequency, 297
- gyro motion, 297*f*
- gyro radius, 297
- gyrocenter, 296, 298

- H_xS_y (hydrogen polysulfide), 130
- H₁₀, 413
- habitability, 506–507, 547
- Hadley cell, 106, 107*f*, 109, 115–117
 - Venus, 116
- Hadley Rille, 170, 172*f*
- half-life, 353
- halides, 154
- halite, 153, 156*f*
- Hall conductivity, 135
- Hall current, 135, 138
- Hall, A., Sr., 215
- Halley, E., 405
- halomethane, 128
- Haser model, 422*f*, 422, 446
- Hawaii, 168*f*, 168, 262
- Hayabusa spacecraft, 195, 395, 398, 399*f*
- hazes, 78
- HC₃N (cyanoacetylene), 130
- HCO₃[–] (bicarbonates), 145
- heat flow parameters, 254
- heat flux, 61, 256
- heat loss, 257–258
- heat sources, 78–80, 167, 254–256
 - gravitational, 254, 535–536
 - internal, 78
- Heisenberg uncertainty principle, 66
- Helene, 233
- heliopause, 5, 7*f*
- Helios spacecraft, 395
- helioseismology, 16, 261
- heliosphere, 5–7, 7*f*
- helium depletion, 98
- Hellas basin, 117
- hematite, 154, 156*f*
- Henyey–Greenstein phase function, 68
- Herbig–Haro objects, 519
- Herschel, 232*f*
- Hertzsprung–Russell (H–R) diagram, 18*f*, 519
- high pressure experiments, 243
- Hill radius, 454*f*
- Hill sphere, 29, 34, 54, 451, 533, 539, 543*f*, 544
- Hill’s problem, 27, 51
- Himalayas, 167
- Hipparcos, 18*f*
- HNO₃ (nitric acid), 194
- Hohmann ellipse, 26*f*
- Hohmann transfer orbit, 25, 51
- homopause, 139
- hoodoos, 442
- horseshoe orbits, 28*f*, 28–30
- horst, 165*f*, 165, 167
- hot spot, 262
- H₂SO₄ (sulfuric acid), 194
- HST (Hubble Space Telescope), 84, 130, 137*f*, 190*f*, 192*f*, 194, 205*f*, 235, 319, 373, 400*f*, 439, 461*f*, 466*f*, 467, 520
- hurricane, 113
- Huygens probe, 229*f*
- Huygens, C., 448
- hydrate minerals, 155
- hydrated silicates, 379, 401, 526
- hydrodynamic escape, 537
- hydrogen bulge, 135, 317
- hydrogen burning limit, 489, 519
- hydrogen, phase diagram, 244*f*, 244
- hydrostatic equilibrium, 63, 76, 109, 138, 241–242, 249–251, 274, 281, 519
- hydroxides, 154, 526
- hyperfine structure, 425
- Hyperion, 234*f*, 234
- hypervelocity impact, 316
- hypocenter, 259

- Iapetus, 152, 233*f*, 233
- IAU definition of a planet, 367
- ice, 155
 - CH₄ (methane), 155
 - CO₂ (carbon dioxide), 155
 - H₂O (water), 155
 - NH₃ (ammonia), 155
 - phase diagram, 245, 246*f*
- Ice Age, 39, 144
 - Little Ice Age, 284
- ice line, 271

- ice/rock ratio, 550
- icy satellites
 - photochemistry, 130
- ideal gas law, 63, 76
- IDPs, 431
- ilmenite, 155
- Image satellite, 136*f*
- Imbrium basin, 265, 315
- IMP spacecraft, 287, 288*f*
- impact crater, *see* crater
- impact cratering, 174–195
- impact erosion, 142, 537
- impacts
 - atmospheric effects, 536
 - classification, 195
 - oblique, 181, 204
- inclination
 - forced, 9
- incompatible elements, 262
- induced magnetotail, 292
- inelastic collisions, 452
- integral of motion, 51
- interference pattern, 569
- interferometry, 494, 496, 498, 569
- interiors, 16, 241–282
- internal heat, 254–258
- interplanetary coronal mass ejection (ICME), 286
- interplanetary dust particles, 345, 346*f*, 352
- interplanetary medium, 48, 283–293
- interstellar cloud, 549
- interstellar grains, 338, 360, 517, 527
- interstellar medium, 516
- interstellar radiation field, 72
- intertropical convergence zone (ITCZ), 115
- invariable plane, 11, 24
- Io, 4, 61, 216, 217*f*
 - Amirani, 220
 - atmosphere, 16, 94, 96*f*, 149
 - composition, 89, 95
 - craters, 185, 187
 - dust stream, 218, 395
 - eclipse, 218
 - heat loss, 257
 - hot spots, 218, 566
 - interior, 271
 - Loki, 221
 - magnetic field, 325
 - moment of inertia ratio, 250
 - neutral cloud, 317–318
 - Pele, 221
 - photochemistry, 130
 - Pillan, 220
 - plasma torus, 316*f*; 318–319
 - Prometheus, 220
 - resonance, 32
 - ribbon, 319
 - sodium cloud, 316*f*, 317, 336
 - surface, 152, 216–221, 220*f*, 239
 - tides, 44, 217, 256
 - Tvashtar, 220
 - volcanism, 167, 218*f*
- ion–neutral reaction, 141
- ionic bond, 153
- ionization, 66, 130–133
- ionopause, 292, 434
- ionosonde, 305
- ionosphere, 80, 130–133, 312
 - conductivity, 134
 - currents, 134
- IRAS (InfraRed Astronomical Satellite), 394*f*, 394
- iron oxide, 154, 156*f*, 526
- irreversible reactions, 160
- IRTF (InfraRed Telescope Facility), 122*f*
- isentropes, 113
- ISO, 424*f*, 431*f*
- isobar, 109, 111*f*, 112
- isochron diagram, 354
- isostatic compensation, 265
- isostatic equilibrium, 251–254
- isotopes, 513
 - anomalies, 358
 - D/H ratio, 278, 360, 538
 - oxygen, 360
 - spectral lines, 91
- isotopic fractionation, 141
- Jacobi constant, 27, 51
- Jacobi ellipsoid, 249*n*[3]
- Jacobi–Hill stability, 34
- jadeite, 239
- Janus, 29, 33, 233, 457, 469
- Jeans escape, 141
- Jeans mass, 518, 549
- joints, 164
- Joule heating, 80, 135
- Jupiter, 2, 16, 26, 51, 113, 439, 513, 544
 - 5 μ m hot spot, 122
 - atmosphere, 15, 83, 149, 245
 - basic parameters, 77
 - composition, 90, 97–100
 - eddy diffusion, 140
 - thermal structure, 80
 - aurora, 136, 137*f*
 - central pressure, 242
 - clouds, 105
 - dynamics, 121
 - formation, 537, 540
 - global upheaval, 123
 - gravitational moments, 250
 - Great Red Spot, 113
 - heat flow, 254
 - images, 121*f*

- Jupiter (*cont.*)
 impacts, 584
 infrared hot spot, 98
 interior, 242, 245, 274–276, 276*f*, 282
 internal heat, 254–255, 258
 ionosphere, 133, 135
 irregular satellites, 225
 lightning, 114
 longitude system III, 317*n*[4]
 magnetic field, 276, 294, 332, 334, 481*f*, 488
 parameters, 294
 magnetosphere, 295, 316*f*, 316–325, 320*f*
 plasma, 296
 magnetospheric plasma parameters, 296
 orbital elements, 5
 photochemistry, 129–130
 physical data: Table 1.3, 6
 radio emission, 283, 321–323, 323*f*, 336
 DAM, 322–324
 HOM, 322–324
 KOM, 324
 synchrotron radiation, 320–322
 VLF, 324–325
 radio spectrum, 99*f*
 reflection spectrum, 97*f*
 resonances, 33, 547
 rings, 5, 327, 395, 448, 453–457, 480, 484–485, 487–488
 Table 11.1, 455
 runaway growth, 534
 satellites
 orbital data: Table 1.4, 8
 physical data: Table 1.5, 10
 SL9 impact, 190
 small moons, 225–226
 temperature, 56, 60, 73
 thermal structure, 79*f*, 83
 winds, 119*f*, 119–126, 150
- Kármán vortex street, 113, 122
Kaguya mission, 197, 266
KAO (Kuiper Airborne Observatory), 424
karst topography, 172
Keck telescope, 124, 125*f*, 126*f*, 192*f*, 221*f*, 454*f*, 461*f*,
 466*f*, 467
Keeler gap, 477*f*
Kelvin–Helmholtz instability, 303
Kepler mission, 599
Kepler’s laws, 7, 11, 22–23, 43–44, 50–51, 388, 445, 449
Kepler, J., 7, 22
kinetic inhibition, 526
kinetic theory, 305
Kirchhoff’s law, 59, 67
Kirkwood gaps, 33*f*, 33, 368, 386*f*, 402
Kirkwood, D., 368
komatiites, 220
Kozai mechanism, 581
Kracht, *see* comets, Sun-grazing
KREEP, 197
Kreutz, *see* comets, Sun-grazing
Kreutz, H., 440
K–T boundary, 193
Kuiper belt objects (KBO’s), 4, 366–404, 410, 427, 438,
 444–445, 513, 542
 classical KBOs, 371
 composition, 382–383
 densities: Table 9.5, 392
 families, 386
 formation, 543, 548
 individual KBOs
 2000 CR₁₀₅, 371, 372*f*
 2006 SQ₃₇₂, 372*f*, 372
 50000 Quaoar, 383*f*, 383
 90377 Sedna, 371, 372*f*, 383
 90482 Orcus, 383
 136108 Haumea, 375, 383, 386, 388, 390*f*, 391
 136199 Eris, 371, 372*f*, 382, 383, 383*f*, 594
 136472 Makemake, 383
 orbital elements: Table 9.2, 373
 origin, 400
 size, 373
 size distribution, 383, 385
 taxonomy, 382–383
Kuiper, G.P., 93, 371
- Lagrange, J.L., 27
Lagrangian points, 27–29, 28*f*, 370, 451, 479, 512
Lambert surface, 59
Lambert’s exponential absorption law, 67
Langmuir waves, 308
Laplace resonance, 271
Laplace’s equation, 26, 37, 247
Laplacian plane, 394, 402, 472
Larissa, 468*f*
Larmor frequency, 297
Larmor radius, 297, 300
laser beacon, 568*f*
late heavy bombardment, 186
latent heat, 78, 101–102, 116, 159, 162
lava channel, 170
lava lakes, 196
lava tube, 170
Legendre polynomials, 37, 247, 295
lenticulae, 222–223
Lenz’s law, 290
Levy, D., 190
Lidov–Kozai mechanism, 581
life, 78, 193–195, 214–215, 342, 506–507, 512
lightcurves, 13, 565
lightning, 114, 361–362
 radio emissions, 308

- limb darkening, 494, 500
- limestone, 158
- limiting flux, 139, 141, 151
- limonite, 154, 156*f*
- Lindemann criterion, 243
- line shape, 85
 - Ben Reuven, 87
 - Debye, 86
 - Lorentz, 86
 - Van Vleck–Weisskopf, 87
 - Voigt, 86, 148
- line transitions, 66
- liquidus, 161*f*, 161
- lithophile elements, 197
- lithosphere, 152, 239, 251, 257, 262, 267
- Loihi, 262
- longitude of periaipse, 24
- loops, 283
- Lorentz force, 296, 298*f*, 298, 334, 479–480, 488
- Lorentz resonances, 471, 480–481
- loss cone, 303, 309
 - drift loss cone, 309
- loss tangent, 71
- Love number, 42, 249
- Love waves, 258, 259*f*
- Lowell, P., 205*f*
- Luna spacecraft, 1, 186, 196, 575*f*
- Lunar Prospector spacecraft, 196, 266*f*
- Lyapunov time, 31–33, 35, 40*f*, 52
- Lyman α , 66, 317
- Lyman limit, 66
- Lyman series, 66
- Mössbauer spectroscopy, 572
- Maat Mons, 170*f*
- Mab, 235, 484
- Maclaurin spheroid, 248
- mafic, 155, 157
- Magellan spacecraft, 174*f*, 188*f*, 200, 202–203, 268
- magma, 152, 155, 159–163, 168, 315
- magmatic differentiation, 162
- magnesiowüstite, 246
- magnesium oxide, 153
- magnetic annihilation, 294
- magnetic anomaly model, 317
- magnetic breaking, 522
- magnetic dipole field, 294–295
- magnetic (dipole) moment, 294–295, 299
- magnetic field, 15, 134, 142, 360, 479, 513, 518, 522
 - configuration, 293–296
 - dynamo theory, 332–333
 - generation, 332–333
 - induced, 292
 - interplanetary, 288*f*
 - multipole expansion, 295–296
 - planetary parameters, 294
 - poloidal, 332
 - reversals, 265
 - toroidal, 332
 - variability, 333
- magnetic induction equation, 290
- magnetic pileup boundary, 292
- magnetic reconnection, 294*f*, 294, 303
- magnetic storm, 313*f*
- magnetism, remanent, 360
- magnetite, 154, 156*f*, 352
- magnetodisk, 316
- magnetohydrodynamic dynamo, 332
- magnetohydrodynamics (MHD), 289
- magnetopause, 292, 309
- magnetorotational instabilities, 524
- magnetosheath, 292, 309–310
- magnetosonic Mach number, 293
- magnetosphere, 283–336
 - comets, 433–435
 - plasma parameters, 296
 - storm, 312
 - substorm, 312
- magnetospheric plasma
 - losses, 303–304
 - sources, 303
- magnetotail, 292–293, 309
- magnitude, 413
 - absolute, 368, 413
 - apparent, 413
- Magnus, A., 489
- main sequence stars, 506, 515
- mantle, 251
- mantle boundary, 292
- marble, 156*f*
- Mare Imbrium, 170, 196
- Mare Orientale, 176*f*, 265
- Mariner 10 spacecraft, 104*f*, 198*f*, 267
- Mariner spacecraft, 91*f*
- Mars, 4, 14*f*, 25, 171*f*, 292, 342, 506–507, 543*f*
 - atmosphere, 16, 83, 149
 - basic parameters, 77
 - composition, 88–93
 - eddy diffusion, 140
 - thermal structure, 79*f*, 81
 - aurora, 315
 - blueberries, 213, 572
 - Borealis basin, 206
 - canals, 204
 - central pressure, 242
 - channels, 204, 208, 209*f*
 - climate evolution, 146, 147*f*
 - clouds, 104
 - CO spectrum, 92*f*
 - craters, 176, 179, 183, 208, 209*f*, 211*f*
 - double, 388
 - dichotomy, 204–205, 314

- Mars (*cont.*)
 - dust, 82*f*
 - dust storms, 117
 - eddies, 112
 - eddy diffusion, 139
 - flood plains, 212
 - frost, 206
 - general circulation models, 117
 - geophysical data: Table 1.2, 6
 - glaciers, 208
 - gravitational moments, 250
 - gullies, 210
 - heat flow, 254
 - hematite, 572
 - hydrodynamic escape, 142
 - interior, 268*f*, 270*f*, 270–271, 282
 - ionosphere, 132, 133*f*
 - life, 507
 - magnetic field, 15, 283, 314, 315*f*
 - meteorites, 339
 - obliquity, 40*f*
 - obliquity variations, 39
 - orbital elements, 5
 - outflow channels, 209
 - photochemistry, 129
 - polar caps, 206, 207*f*
 - polarization, 377
 - rampart craters, 208
 - rocks, 158
 - rotation, 206
 - rovers, 572
 - satellites, 545
 - orbital data: Table 1.4, 8
 - physical data: Table 1.5, 10
 - surface, 152, 168, 171, 173, 174, 174*f*, 186*f*, 203–216, 205*f*, 213*f*
 - tectonics, 167, 206
 - temperature, 62, 70, 74, 82*f*
 - thermal skin depth, 62
 - thermal spectrum, 91, 92*f*
 - uncompressed density, 242
 - volcanism, 169, 170*f*, 206
 - winds, 107, 117, 173, 210
- Mars Exploration Rovers, 82, 194, 212
- Mars Express, 93, 195, 315
- Mars Express spacecraft, 138, 216*f*
- Mars Global Surveyor spacecraft, 82*f*, 204, 211*f*, 314
- Mars Odyssey spacecraft, 208
- Mars Pathfinder spacecraft, 210
- Mars Reconnaissance Orbiter, 195
- Mars rover Spirit, 117*f*
- mascon, 265
- mass, 11–12
- mass anomalies, 251–254
- mass extinction, 193
- mass fractionation, 513
- mass function, 538
- mass movement, 164
- mass spectrometry, 573
- mass wasting, 164, 171
- Mauna Loa, 169, 171*f*, 201
- Maunder minimum, 284
- Maxwell Montes, 171*f*
- Maxwell’s equations, 290
- Maxwellian distribution, 86, 140, 296, 391, 514
- Mayor, M., 499
- McIlwain’s parameter, 299
- mean intensity, 65
- mean lifetime, 353
- mean motion resonances, 35
- melt glass, 183
- Mercury, 4, 13, 25, 51–52, 198*f*, 535, 548
 - atmosphere, 16, 76, 84, 94, 141–142
 - basic parameters, 78
 - composition, 89, 95
 - central pressure, 242
 - craters, 176, 184–185
 - formation, 535
 - geophysical data: Table 1.2, 6
 - gravitational moments, 250
 - heat flow, 254
 - interior, 250, 267–268, 268*f*
 - magnetic field, 15, 283, 292, 294, 313–314, 314*f*, 591*f*
 - generation, 333
 - parameters, 294
 - magnetospheric plasma parameters, 296
 - orbit, 43*f*
 - orbital elements, 5
 - phase function, 374
 - polarization, 377
 - precession, 52
 - radar image, 199*f*
 - radar observations, 571
 - radio image, 199*f*
 - rotation, 44
 - surface, 71, 152, 186*f*, 197–200, 377
 - tectonics, 167
 - temperature, 59, 62*f*, 62, 73
 - thermal skin depth, 62
 - tides, 43
 - uncompressed density, 242
 - water-ice, 199, 587
- mesopause, 78, 81
- mesosiderites, 339
- mesosphere, 78, 81, 83
- MESSENGER spacecraft, 95, 198*f*, 199, 267
- metallic hydrogen, 244, 247, 255, 276–278
- metallicity, stellar, 506*f*
- meteor, 184–185, 337, 347, 394
- shower, 394

- Meteor Crater, 175*f*, 175, 348
meteor stream, 416
meteorites, 15–16, 18, 175, 214, 337–365, 513,
 542, 548
 enstatite, 380
 eucrite, 339, 381, 592
 HED, 358
 iron, 337, 339, 357, 367
 L chondrites, 344
 primitive, *see* chondrites
 stone, 337
 stony-iron, 337
meteorology, 106–126
meteors
 Leonids, 394
 Perseids, 394
Metis, 225, 227*f*, 454*f*, 484
Meyer, *see* comets, Sun-grazing
MHD waves, 304–306
mica, 154
microlensing, 495–496
micrometeorites, 345, 346*f*
mid-ocean ridge, 166, 264, 315
migration, 540–543, 546, 548–549
Milankovitch cycles, 39, 144
Mimas, 33, 231, 232*f*, 457, 465, 469, 476
 surface, 152
mineralogy, 153–155
minerals, 153–155
 chemical classes, 154
minimum mass protoplanetary disk, 521, 529*f*, 532, 534, 540,
 543, 549, 551
Miranda, 235, 236*f*
mirror point, 297
mixing ratio, *see* volume mixing ratio
Mohorovičić discontinuity, 262
Mohs scale of hardness, 153–154
MOLA, 204, 205*f*
molar heat capacity, 61
molecular cloud, 18, 517–519
molecular viscosity, 523, 550
molecules
 lifetime, 415
moment of inertia ratio, 42, 249–250
Mono Lake, 169
monsoon, 116
Monte Carlo model, 422*f*, 422
Moon, 1, 4–5, 11, 16, 157, 164, 168, 170, 174,
 188, 357, 548
 atmosphere, 16, 83, 94, 141–142
 basic parameters, 78
 composition, 89, 95
 central pressure, 242
 craters, 176, 182, 184–185, 388
 Earth–Moon system, 27
 Eu anomaly, 197
 formation, 535, 545
 gravitational moments, 250
 highlands, 196–197
 interior, 241, 242, 265–267
 internal heat, 258
 loss tangent, 71
 magnetic field, 15, 283, 315
 maria, 152, 155, 169, 196–197, 206
 meteorites, 339
 opposition effect, 565
 phase function, 374, 566*f*
 polarization, 566
 rocks, 512
 seismology, 261, 267*f*
 surface, 169*f*, 172*f*, 176*f*, 182–183, 185, 186*f*, 192, 196–197,
 202, 217, 374, 377
 symbol, 5
 tectonics, 167
 temperature, 59
 thermal skin depth, 62
 tides, 39–41, 53
 uncompressed density, 242
moonquakes, 39, 164, 266–267
Mount Etna, 169
Mount Everest, 171*f*
Mount Shasta, 169
Mount St. Helens, 167*f*, 169
Mount Vesuvius, 169
mudstone, 158
multiple scattering, 565
mutual events, 373, 566

N-body problem, 51, 534
Navier–Stokes equation, 108
NEAR (Near-Earth Asteroid Rendezvous) spacecraft, 195, 395,
 397, 398*f*
NEOs, 194*f*, 401
Neptune, 3, 12, 513, 543
 atmosphere, 15, 85
 basic parameters, 77
 composition, 90, 97–100
 eddy diffusion, 140
 Great Dark Spot, 126*f*
 Little Dark Spot, 126*f*
 Scooter, 126*f*
 central pressure, 242
 clouds, 105
 dynamics, 125
 eddy diffusion, 140
 formation, 537, 540
 gravitational moments, 250
 heat flow, 254
 images, 126*f*
 interior, 255, 276–278, 277*f*

- Neptune (*cont.*)
 internal heat, 254–255, 258
 ionosphere, 133
 magnetic field, 278, 294, 296, 330*f*, 330, 332
 generation, 333
 parameters, 294
 magnetospheric plasma parameters, 296
 orbit, 51
 photochemistry, 129–130
 physical data: Table 1.3, 6
 radio emission, 331*f*, 331, 336
 reflection spectrum, 97*f*
 resonance, 33, 35
 rings, 5, 448, 467, 468*f*, 479, 485, 566
 Table 11.4, 469
 satellites, 236–238
 orbital data: Table 1.4, 8
 physical data: Table 1.5, 10
 temperature, 56, 60
 thermal structure, 79*f*, 83
 winds, 119–126, 120*f*
Nereid, 236
neutron star, 516
neutrons
 epithermal, 573
 fast, 573
 thermal, 573
New Horizons spacecraft, 220, 395, 448
Newton’s laws, 7, 22–23, 50
Newton, I., 22, 37
N₂H₄ (hydrazine), 129
(NH₄)_xS_y (ammonium polysulfide), 130
nightglow, 135
Nimbus spacecraft, 91*f*
NO (nitric oxide), 128
noble gases, 98, 143
nongravitational force, 408–409, 412, 445
nova, 202
nuclear fusion, 17–18, 514, 519
nuclear spectroscopy, 571–572
nuclear winter, 151
nucleosynthesis, 349, 356, 360, 514–517
 CNO cycle, 515
 p-process, 516
 pp-chain, 515
 r-process, 355–356, 365, 516
 s-process, 516
nuclides
 half-lives, 353
nulling, 496
Nusselt number, 257
nutation, 251, 261, 394

O₃ (ozone), 127–129
Oberon, 235, 236*f*

oblate, 39
oblateness, 249, 469
obliquity, 13, 544
Observing bands
 Table E.1, 566
observing techniques, 391, 565–574
obsidian, 156*f*, 169
occultation, 566
occultation experiments, 567*f*
occultation techniques, 566–568
ocean, 78, 251
ocean acidification, 145
Odin satellite, 425
Ohm’s law, 290
Ohmic dissipation time, 291
Ohmic heating, 256
olivine, 154, 352, 526
Olympus Mons, 117, 169–170, 171*f*, 206
Oort cloud, 4, 368, 409–534
 formation, 543, 548
Oort, J., 409
Ophelia, 235, 478
opposition, 570n[1]
opposition effect, 376, 565
optical depth, 67
orbital elements, 5, 24
 Jacobi, 36*f*
 proper, 385
orbital migration, 509
Orientale basin, 182, 196
oxidation, 129
oxides, 154
ozone, 127–129

P waves, 258–259, 260*f*
pahoehoe, 168*f*, 168
PAHs, 214, 526
palimpsests, 183, 224
pallasites, 339
Pan, 457, 459, 463, 474, 477*f*, 477–478, 487–488
pancake-like domes, 201
Pandora, 233, 478*f*, 478
Pangaea, 165*f*, 165
Pantheon Fossae, 199
parallax, 405
Parker spiral, 287*f*
Parker’s solar wind solutions, 286*f*
Parker, E., 286
partial pressure, 121
particle precipitation, 79
particle-in-a-box approximation, 531
partition function, 66
Paschen series, 66
Pauli exclusion principle, 66, 490
Pederson conductivity, 135

- Pederson current, 135
- Pele, 218*f*
- perfect gas law, 63
- periclase, 162*f*
- peridotite, 155, 246
- perigee, 24
- perihelion, 22, 24
- permafrost, 173
- perovskite, 246, 525
- petrographic type, 338
- petrology, 153
- phase angle, 58–59
- phase diagram, 159–161, 161*f*
 - hydrogen, 244*f*, 244
 - ice, 245, 246*f*
 - iron, 246
- phase function, 495
- phase integral, 59
- phase velocity, 305
- Phobos, 14*f*, 42, 53, 215–216, 216*f*, 374, 545
- Phoebe, 233, 235*f*, 457
- Phoenix spacecraft, 206, 208, 210*f*
- phonons, 256
- phosphates, 154
- photochemical equilibrium, 126
- photochemistry, 126–138
 - CH₄ (methane), 130
 - CO₂ (carbon dioxide), 132
 - H₂ (hydrogen), 132
 - H₂S (hydrogen sulfide), 130
 - NH₃ (ammonia), 129
 - PH₃ (phosphine), 130
- photodissociation, 81, 126–130
- photoelectrons, 79
- photoevaporation, 521*f*, 527
- photoionization, *see* ionization
- photolysis, *see* photodissociation
- photometry, 494, 565
- photosphere, 84
- pinnacles, 442
- Pioneer spacecraft, 395, 448
- Pioneer Venus Orbiter, 268
- pit, 175
- pitch angle, 297–298
- pitch angle diffusion, 304
- Planck radiation, 57–58, 71, 83
- planet
 - IAU definition, 366, 489
- planet, dwarf
 - IAU definition, 366
- planetary embryos, 531–534
- planetary rotation, 512, 543
 - origin, 551
- planetesimals, 19, 49, 349, 358, 367, 527–534, 537, 548, 550
 - collisions, 531–533
 - formation, 528–531
 - timescales, 527
- plasma, 296–304
- plasma drag, 480
- plasma sheet, 309–310, 319, 330
- plasma waves, 305–306
- plasmopause, 311
- plasmasphere, 309–311
- plasmoid, 313
- plasticity, 241
- plate tectonics, 16, 145, 165–167, 166*f*
- playa, 173
- plutinos, 371, 542, 548
- Pluto, 4–5, 11, 95, 371, 383*f*, 399–400, 400*f*, 542–544, 566, 593
 - atmosphere, 16, 76, 94
 - basic parameters, 78
 - composition, 89, 95
 - moons, 391*f*
 - orbit, 35, 37
 - Pluto–Charon system, 27, 43, 545
 - resonance, 33
 - surface, 399
 - symbol, 5
 - winds, 107
- plutoids, 367
- Poincaré, H., 31
- Poisson’s equation, 26, 290
- polar cap, 294
- polar wander, 251
- polar wind, 142, 310
- polarimetry, 376–377, 566
- pole star, 39
- Polydeuces, 233
- polygon, 173
- polymict, 184*f*
- polytropic index, 247
- population inversion, 426
- Portia group, 235
- post-glacial rebound, 254
- postperovskite, 246, 263
- Poynting–Robertson drag, 45–47, 74, 344, 387, 401, 455, 479–480, 484, 520
- pp-chain, 515
- Pratt hypothesis, 252–253, 280
- pre-main-sequence stars, 519
- precession, 20, 251
 - lunisolar, 20
 - torque-free, 393
- PREM model, 261, 262*f*
- presolar grains, 349–350, 352, 356, 359, 360, 360*f*
- pressure broadening, 86
- pressure, Table 6.1, 242
- primitive solar nebula, 520
- principal axes, 393

642	Index
principal quantum number, 65 prograde rotation, 13 Prometheus, 218<i>f</i>, 233, 459, 476–478, 478<i>f</i> prominence, 283, 285<i>f</i> proplyds, 519 Proteus, 238 proto-atmosphere, 536 protoplanetary disk, 18, 49, 359–361, 520–527, 534, 539, 543, 547, 550 chemistry, 524–527 minimum mass, 521 protoplanets, 523, 534 protostar, 514, 519 Proxima Centauri, 20 Puck, 235 pulsar, 492, 498, 512, 549 pumice, 156<i>f</i>, 158 Pwyll, 224<i>f</i> pyrite, 155 pyroclast, 157 pyroxene, 154, 352, 526 quartz, 154, 239 quasi-satellites, 30 Queloz, D., 499 radar observations, 375–377, 569–571 bistatic, 570 monostatic, 570 Radau–Darwin approximation, 249 radial diffusion, 304 radiation, 61, 64–72, 80 radiation belts, 293, 309, 311, 316 radiation drag, 48 radiation field, moments, 65 radiation pressure, 45–46, 46<i>f</i>, 54, 74, 405, 423, 479 radiative equilibrium, 68–70, 80 radiative transfer, <i>see</i> atmosphere; surface radiative–convective equilibrium, 70, 81 radio astronomy, 569 radio emissions, 306 radio radiation low frequency, 306–308 radio telescope, 507 radio waves, 304–306 radioactive decay, 256, 352, 513, 552 radioactive heating, 256 radioactivity, 352–357, 401 radiolysis, 187 radiometry, 374–375, 565–566 radionuclide dating, 341, 352–357, 512 extinct nuclei, 355 extinct nuclide, 355, 527 rain, 102 Rankine–Hugoniot conditions, 177	Rankine–Hugoniot relations, 290 rarefaction wave, 178 Rayleigh distribution, 368 Rayleigh mixing formula, 571 Rayleigh number, 257 Rayleigh scattering, 583<i>f</i> Rayleigh waves, 258, 259<i>f</i> Rayleigh–Jeans law, 57 Rayleigh–Taylor instability, 304 reaction rate, 127 recombination, 126–130, 141 red giant, 516 red shift, 86 REE (Rare Earth Elements), 525 reference gravity formula, 248 reflectance, 59 regolith, 179, 183, 187, 197, 400 relative humidity, 101 relativistic correction factor, 297, 308 relativity, 408 remanent ferromagnetism, 15, 314 reseau markings, 482<i>f</i> resolution, 568–569 resonance overlap criterion, 34 resonances, 32–34, 197, 368, 458, 468–471, 547 <i>v</i>₆, 368–369 Lindblad, 461<i>f</i>, 469–470 471<i>f</i>, 474, 479, 487 Lorentz, 455, 480, 481<i>f</i> secular, 368 resonant orbits, 503 response coefficient, 249 retrograde, 11, 13 reversible reactions, 159 Reynolds number, 49, 111 magnetic, 291 Rhea, 97, 231, 232<i>f</i> craters, 185 rheidity, 164 rheology, 164, 241 rhyolite, 156<i>f</i> Richter scale, 166, 175, 239 ridged plains, 222 rigidity modulus, 249 rille, 165 ring atmosphere, 483 ring current, 299, 310–311 Ring of Fire, 167 rings, 448–488, <i>see individual planet</i>, rings ringwoodite, 246 river, 172 Roche limit, 41, 190, 448–451, 453, 459, 483–484, 486, 544 Roche, E., 451 rockets, 26 rocks, 155 extrusive, 155

- igneous, 155–158, 157*f*
- intrusive, 155
- metamorphic, 156*f*, 158
- plutonic, 155
- primitive, 155
- sedimentary, 156*f*, 158
- volcanic, 155
- ROSAT (Röntgen) satellite, 435, 436*f*
- Rosetta spacecraft, 395, 398, 425, 595
- Rossby deformation radius, 112
- Rossby number, 109
- Rossby wave, *see* waves
- Rosseland mean opacity, 69, 524*f*
- Rossiter–McLaughlin effect, 502, 503*f*, 602, 604*f*
- rotation, 13
 - origin, 543
- runaway accretion, 531, 533–534, 549, 551
- rupes, 197
- Rydberg constant, 65
- S waves, 258–259 260*f*
- salt, 158
- saltation, 117, 173
- SAMPEX, 312
- San Andreas fault, 167
- sandblasting, 173, 187, 532
- sandstone, 156*f*, 158
- satellite porosity, 273
- satellite wake, 477
- satellites
 - artificial, 49
 - Galilean, 544
 - irregular, 544
 - origin, 544–546
 - quasi-satellites, 30
 - regular, 544
- saturated air, 100
- saturated vapor pressure, 100, 121
 - H₂O (water), 101*f*
- saturation, 185, 187
- Saturn, 3, 16, 26, 53, 449*f*, 457, 513, 544
 - atmosphere, 15, 245, 471
 - basic parameters, 77
 - composition, 90, 97–100
 - eddy diffusion, 140
 - aurora, 137*f*, 137
 - central pressure, 242
 - clouds, 105
 - dynamics, 123
 - F ring, 597*f*
 - formation, 537, 540
 - gravitational moments, 250
 - heat flow, 254
 - images, 124*f*
 - interior, 245, 274–276, 276*f*, 282
 - internal heat, 254–255, 258
 - ionosphere, 133, 135
 - lightning, 114, 124
 - magnetic field, 276, 294–295, 325–328, 332, 471, 481
 - parameters, 294
 - plasma, 296
 - magnetospheric plasma parameters, 296
 - orbital elements, 5
 - photochemistry, 129–130
 - physical data: Table 1.3, 6
 - radio emission, 328–329, 336
 - reflection spectrum, 97*f*
 - resonance, 33
 - rings, 5, 12, 33, 54, 135, 325, 395, 448, 451–453, 457–465, 467, 469, 471, 474–476, 483–485, 523
 - atmosphere, 94, 97
 - A ring, 457–458, 460*f*, 462, 464, 469, 470*f*, 471, 472*f*, 474, 476–477, 477*f*, 483, 485, 488
 - B ring, 457–458, 460–465, 461*f*, 469, 474, 476, 481, 482*f*, 483, 485
 - C ring, 457, 460*f*, 462, 464, 471, 474, 483
 - Cassini division, 457, 464, 474, 483
 - Columbo gap, 460*f*
 - D ring, 457, 460*f*, 471
 - E ring, 97, 457–458, 461*f*, 461, 464, 479, 485
 - Encke gap, 457–459, 477*f*, 477–478, 487–488
 - F ring, 234, 457–458, 461, 463, 477–478, 478*f*, 488
 - G ring, 457–458, 461*f*, 471
 - Keeler gap, 457, 463, 477–478
 - particle size distribution, 462
 - Phoebe ring, 457
 - propeller features, 460*f*, 463*f*, 463
 - Roche division, 457
 - spokes, 458, 481, 482*f*, 488
 - Table 11.2, 456
 - satellites, 273
 - orbital data: Table 1.4, 8
 - physical data: Table 1.5, 10
 - SED, 114, 124
 - SKR, 137
 - small satellites, 233
 - temperature, 56, 60
 - thermal structure, 79*f*, 83
 - winds, 119*f*, 119–126
 - scale height, 76, 318, 522
 - giant planets, Table 4.2, 77
 - terrestrial planets, 77–78
 - scarp, 165
 - scattered disk, 4
 - scattered disk objects, 371
 - scattering, 67
 - anisotropic, 68
 - Henyey–Greenstein, 68
 - isotropic, 68

- scattering (*cont.*)
 - Mie scattering, 68
 - multiple, 68
 - Rayleigh, 68
 - single, 68
- scattering angle, 58, 59*f*
- scattering phase function, 68
- schist, 156*f*
- Schwarzschild radius, 52
- scintillation, 495
- sea floor spreading, 166, 262, 315
- sea level, mean, 163
- secular resonances, 35
- seeing, 568
- seeping, 173
- seismic discontinuity, 246
- seismology, 16, 258*f*, 258–261
- SELENE spacecraft, 197, 266
- self-compression model, 261
- self-gravitating clumps, 459
- self-shielding, 349
- Serenitatis basin, 315
- serpentine, 352
- serpentinite, 158
- serpentinization, 93
- SETI, 507
- shadow zone, 260*f*
- shale, 158
- shape, 13–14
- shape of body, 241
- shear modulus, 249, 259
- shell degeneracy, 299
- shell splitting, 299
- shepherding, 234–235, 476–478, 520
- shield volcano, 169
- shock wave, 178
- shock wave experiment, 243, 245–246
- shocks, 289–290, 362, 522, 525
- Shoemaker, C., 190
- Shoemaker, G., 190
- siderial, 20
- siderophile elements, 197
- silica, 162*f*, 238
- silicates, 154
- silicic, 155
- single scattering albedo, 68
- sintering, 440
- sinuous rille, 172*f*, 202
- size, 12–13
- skin temperature, 70
- slate, 156*f*
- slumping motion, 164, 181
- smog, 83
- SMOW (standard mean ocean water), 349*f*
- Snell’s law of refraction, 71
- SOHO (Solar and Heliospheric Observatory), *see also* comets,
Sun-grazing, 440, 441*f*, 594*f*
- solar constant, 59
- solar cycle, 284
- solar eclipse, 21, 284*f*
- solar flare, 286
- solar luminosity, 59–60
- solar maximum, 284
- Solar Maximum Mission, 285*f*
- solar nebula, 520–527
- solar sunspot cycle, 284*f*
- solar wind, 5, 48, 283–293, 291*f*, 303, 312, 313*f*, 334, 387, 433,
435, 548
 - magnetic field, 287
 - parameters, 286
- solar wind–planet interactions, 291–293
- solar wind sweeping, 142
- solidus, 161*f*, 161
- sound speed, 286
- source function, 67
- South Atlantic Anomaly, 309
- South Pole Aitken Basin, 196
- space weather, 288, 316, 380–381
- space weathering, 381
- spallation, 514
- spatter cones, 169
- specific heat, 61, 102
- specific intensity, 57, 64
- specific volume, 64
- speckle imaging, 194, 568
- spectroscopy, 565
- spectrum, 84*f*
- speed of light, 57
- spheroidal mode, 260
- spin-orbit resonance, 43*f*, 548
- spinel, 155
- spiral arm of galaxy, 518
- spires, 442
- Spitzer telescope, 394, 431*f*
- spokes, *see* Saturn, rings
- sputtering, 94, 141, 187
- standing waves, 260
- star formation, 517–519
- Stardust mission, 401, 421, 430–432, 432*f*, 441*f*, 441
- stars, 16
 - AGB, 356
 - luminosity, 17
 - main sequence, 17
 - variable, 493
- statistical weight, 66
- Stefan–Boltzmann law, 58, 60, 70
- stellar age, 519
- stellar wind, 516
- steradian, 64
- Stokes coefficients, 247

- Stokes equation, 102
- storms, 111–114
- strain, 164
- stratigraphy, 188
- stratopause, 78, 83
- stratosphere, 64, 78
- streamer, 283
- strewn field, 184, 347
- subduction zone, 166
- sublimation, 100
- Submillimeter Wave Astronomy Satellite (SWAS), 425
- substorms, 136
- sulfates, 154
- sulfides, 154
- Sun, 2, 14, 16, 23–24, 26, 41, 46, 52, 85, 90, 144, 254, 284, 285*f*, 361, 504, 519
 - photosphere, 21
 - spectrum, 58*f*
- sunspots, 283, 284*f*
- supernova, 18, 355–356, 516
- supersaturation, 101
- surface
 - composition, 15
 - radiative transfer, 70–72
- surface gravity, 248, 253
- surface waves, 258, 260*f*
- Swings effect, 424–426
- swirl albedo, 315
- synchrone, 418
- synchronous orbit, 189
- synchronous rotation, 43–44
- synchrotron radiation, 307*f*, 308–309
- syndyne, 418
- synodic period, 53
- synthetic Uranus, 277
- T-Tauri stars, 144, 256, 361, 401, 519, 527, 541
- tadpole orbits, 28*f*, 28–30, 479
- TAOS, 385
- Taylor columns, 120
- tectonic plates, 163
- tectonics, 146, 164–167, 197
- tektites, 341
- Telesto, 233
- temperature, 14, 56
 - brightness, 58, 71
 - central: Table 6.1, 242
 - effective, 58
 - equilibrium, 60, 70
 - equivalent potential, 112
 - giant planets: Table 4.2, 77
 - potential, 111, 114
 - terrestrial planets, 77–78
- temperature gradient, 61
- terminal cataclysm, 186
- terminal ion, 132
- terminal velocity, 102, 184
- termination shock, 312
- terrestrial age, 357
- Tethys, 27, 33, 231, 232*f*
- Tharsis, 282
- Tharsis region, 117, 146, 206, 270
- Thebe, 225, 227*f*, 455, 480, 484
- THEMIS spacecraft, 303, 313
- thermal conductivity, 61
- thermal diffusion equation, 61
- thermal diffusivity, 61, 257
- thermal excitation, 67
- thermal expansion coefficient, 257
- thermal heat capacity, 61, 63
- thermal inertia, 61
- thermal radiation, 57–58
- thermal skin depth, 61
- thermal structure, 76–78, 80–83
- thermal tides, 107
- thermal wind equation, 110–111
- thermochemical equilibrium, 526
- thermodynamic equilibrium, 66–67
 - local, 67–68
- thermodynamics, first law, 63–64
- thermonuclear fusion, *see* nuclear fusion
- thermosphere, 78, 80, 117
- tholins, 130, 229
- three-body problem, 26–29, 28*f*, 31*f*, 34, 51
- tidal disruption, 545
- tidal force, 256
- tidal heating, 61
- tides, 33, 39–45, 41*f*, 42*f*, 53–54, 115, 387, 448–451
- tiger stripes, 229
- Tisserand parameter, 411, 591
- Titan, 4, 33, 472, 544
 - atmosphere, 16, 82–83, 135
 - basic parameters, 77
 - composition, 88, 93
 - eddy diffusion, 140
 - clouds, 104
 - cryovolcanism, 229
 - exosphere, 83
 - global circulation models (GCM), 118
 - greenhouse/anti-greenhouse effect, 70, 82
 - Huygens probe, 82
 - interior, 273
 - ionosphere, 83
 - magnetic field, 327
 - mesosphere, 83
 - photochemistry, 130
 - surface, 173, 226–229, 230*f*
 - temperature, 70
 - thermal spectrum, 94*f*
 - thermal structure, 79*f*, 82

- Titan (*cont.*)
 - tropopause, 83
 - winds, 110, 117
- Titania, 235, 236*f*
- tomography, 258, 263
- Toomre’s stability parameter, 452, 523, 538
- topography, 163
- toroidal mode, 260
- TRACE (Transition Region and Coronal Explorer), 285*f*
- trade winds, 109, 115–116
- trans-neptunian objects (TNO), 366–404, *see also* Kuiper belt objects (KBOs)
- transit timing, 495
- transit timing variations, 599
- transits, 494–495, 566
- triple alpha process, 516
- Triton, 4–5, 11, 16, 42, 95, 152, 169, 236–237, 237*f*, 274, 330, 513, 544–545, 548
 - atmosphere, 89, 94–95, 97
 - tides, 256
 - winds, 107
- troilite, 155, 525
- tropical year, 20
- tropopause, 78, 83
- troposphere, 64, 78, 83, 89
- true anomaly, 24
- true polar wander, 206
- tuff, 158
- Tunguska event, 185–186, 193, 195, 204, 348
- turbopause, 139
- turbulence, 530
- Tvashtar Patera, 218*f*
- two-body approximation, 532
- two-body problem, 22–26, 52
- Tycho crater, 180*f*
- ultra mafic magma, 219
- Ulysses spacecraft, 395
- Umbriel, 235, 236*f*
- uncompressed density, Table 6.1, 242, 512
- Universe, 514
 - origin, 512
- Uranus, 3, 12–13, 512–513, 548
 - μ ring, 485
 - atmosphere, 15, 85
 - basic parameters, 77
 - composition, 90, 97–100
 - eddy diffusion, 140
 - central pressure, 242
 - clouds, 105, 149
 - dynamics, 125
 - formation, 537, 540
 - gravitational moments, 250
 - heat flow, 254
 - hydrogen corona, 329
 - images, 125*f*
 - interior, 255, 276–278, 277*f*,
 - internal heat, 255
 - ionosphere, 133
 - magnetic field, 278, 294, 296, 329*f*, 329, 330*f*, 332
 - generation, 333
 - parameters, 294
 - magnetospheric plasma parameters, 296
 - orbit, 51
 - orbital elements, 5
 - photochemistry, 129–130
 - physical data: Table 1.3, 6
 - radio emission, 99*f*, 331*f*, 331
 - reflection spectrum, 97*f*
 - rings, 5, 54, 448, 450*f*, 451, 465*f*, 465–466
 - Table 11.3, 465
 - satellites, 234–236, 274, 545
 - orbital data: Table 1.4, 8
 - physical data: Table 1.5, 10
 - thermal structure, 79*f*, 83
 - UED, 114
 - winds, 119–126, 120*f*
- Urey weathering, 145*f*, 145, 158
- uv*-plane, 569
- vacuum, 76
- valence electrons, 153
- Valhalla structure, 182
- valley of nuclear stability, 516
- Vallis Marineris, 206
- Van Allen belts, *see also* radiation belts, 293, 309, 311*f*, 311
- Van Allen, J., 311
- van der Waals force, 153, 247, 528, 530
- Van Vleck, J.H., 87
- Van Vleck–Weisskopf profile, 87*f*
- vapor partial pressure, 100
- vapor plume, 178
- Vega (α Lyrae), 520
- Vega spacecraft, 421, 431, 434
- velocity
 - Alfvén, 293, 306
 - drift, 299, 301–303
 - electric field, 300
 - field line curvature, 300
 - gradient B, 299
 - gravity, 300
 - escape, 25
 - radial velocity measurements, 489, 493, 510
 - sound, 286
 - terminal, 414
 - velocity dispersion, 452, 532
- Venera spacecraft, 91*f*, 200*f*, 200
- Venus, 4, 13, 25, 51, 171*f*, 292, 433, 512
 - atmosphere, 15, 60, 81, 83, 184
 - basic parameters, 77

- composition, 88–93
- eddy diffusion, 139–140
- H₂SO₄ (sulfuric acid), 129
- thermal structure, 79*f*, 81
- catastrophic resurfacing, 269
- central pressure, 242
- climate evolution, 146, 147*f*
- clouds, 101, 103–104
- CO spectrum, 92*f*
- craters, 182, 203
- cryosphere, 81
- erosion, 203
- geophysical data: Table 1.2, 6
- gravitational moments, 250
- heat flow, 254
- hydrodynamic escape, 142
- images, 104*f*
- impact craters, double, 388
- interior, 250, 268*f*, 268–270
- ionosphere, 132, 133*f*
- life, 507
- lightning, 114
- magnetic field, 15, 283, 314
- mesosphere, 81
- orbital elements, 5
- photochemistry, 129
- polar collar, 104
- superrotation, 116
- surface, 152, 168, 170*f*, 173, 174*f*, 185, 186*f*, 188*f*, 200*f*, 200–204, 202*f*, 203*f*, 204*f*
- tectonics, 167, 203
- temperature, 14, 59–60, 70
- thermal spectrum, 91*f*, 93*f*
- tides, 44
- uncompressed density, 242
- volcanism, 201
- winds, 106, 110, 116
- Venus Express spacecraft, 104, 203
- vernal equinox, 24*n*[1]
- vertical frequency, 39
- vesicular rock, 158
- Viking spacecraft, 210, 213*f*, 214, 216, 342
- virial theorem, 51, 490, 518
- vis viva equation, 24–25
- viscoelastic relaxation time, 164
- viscoelasticity, 164
- viscosity, 157, 164, 523, 541, 550
- viscous diffusion, 478
- viscous instability, 452
- viscous overstability, 452
- visibility data, 569
- VLA (Very Large Array), 122*f*, 124–126, 126*f*, 320, 323*f*, 459, 569, 571, 572*f*
- VLBI (very-long baseline interferometry), 165
- volcanic foam, 158
- volcanism, 16, 45, 78, 167–169
 - effusive, 168
 - explosive, 168
- volume mixing ratio, 88
- vortex, 112
- vorticity, 108–109
 - potential, 113
- Voyager spacecraft, 12, 80, 95, 106, 121*f*, 121, 125, 126*f*, 169, 218, 235, 236*f*, 238–239, 448, 465, 474, 475*f*, 477*f*
- vugs, 214
- vulcan planets, 499, 503, 542, 546
- Walker circulation, 116
- warm plasma, 305
- water, 526
- wave theory, 305
- wavefront, 568
- waves, 115, 304–306
 - gravity, 115
 - planetary, 115–116
 - Rossby, 115, 122
 - seismic, 115
 - sound, 115
- weathering, 173
- Weisskopf, V.F., 87
- Whipple, F., 440
- whistlers, 308, 311
- white dwarf, 18, 509
- Widmanstätten pattern, 339
- Wien law, 57
- Wilson cycle, 166
- wind equations, 108
- wind shear, 110
- wind streak, 173, 203
- winds, 106–126, 173
 - easterly, 107*f*
 - westerly, 107*f*
- Wisdom, J., 33
- Wolszczan, A., 498
- X-ray fluorescence, 571
- X-wind model, 362*f*, 362
- Yarkovsky effect, 45, 47, 344, 370, 389, 408
- Yellowstone, 169–170, 171*f*
- Yohkoh spacecraft, 285*f*
- YORP, 45, 47–48
- Z machine, 243
- zero-velocity surface, 27
- zodiacal cloud, 4, 497*f*
- zodiacal light, 47, 394
- zonal harmonics, 248–249
- zonal winds, 109–110
- zoned crystals, 162