

Index

- accretion disk, *see* disk
- adiabatic temperature gradient, 228
- aerodynamic drag, 142–144
- albedo, 19
- Alfvén velocity, 111
- aluminium (^{26}Al), in Solar Nebula, 78
- angular momentum deficit, 275
- angular momentum problem (star formation), 3, 50
- angular momentum transport, 90, 98, 102–127
- asteroids, 6
- astrometry, 26
- atmosphere, condition for formation, 222
- azimuthal drag, 149–153
- azimuthal velocity (gas disk), 60, 150
- Balbus–Hawley instability, 109
- barotropic disks, 108
- binary systems, Kozai resonance, 272
- blackbody spectrum, 20
- Bode’s law, 289
- boundary layer, 91
- brown dwarf, 1
- Brownian motion, 161
- carbonate–silicate cycle, 45
- catastrophic disruption (threshold in collisions), 186
- chaos
 - Solar System, 270
 - three-body problem, 285
- Chiang–Goldreich model (of protoplanetary disks), 68
- chondritic meteorites, 16
- circulation (of resonant argument), 269
- co-rotation radius, 138
- coagulation equation, 207–210
 - analytic solutions, 208
 - discrete form, 207
 - dust growth, 163
 - integral form, 164
 - runaway growth, 208
- collisional cascade, 293–298
 - size distribution, 297
- collisions, inelastic, 204
- condensation sequence, 73–74
- conductivity, 115
- continuity equation, 109
- convective stability, 227
- cooling time scale, of disk, 243
- core accretion, 221–237
 - dilute core, 239
 - core mass, dilute, 239
 - cosmic rays, flux, 78
 - Coulomb logarithm, 201
 - critical core mass, 230
 - analytic expressions for, 236
- dead zone, 114
- debris disks, 293–300
 - collisional cascade, 293–298
 - time evolution, 298
 - white dwarf, 299
- deuterium-burning threshold, 1
- diffraction limit, 20
- diffusion approximation, 71, 97, 226
- diffusion equation, 90
- diffusivity, 114
- disk
 - α model, 100
 - angular momentum transport, 102
 - debris, 87
 - dispersal, 133
 - evolution equation, 88
 - flaring, 59, 63–65
 - frequency in young clusters, 86
 - gas temperature, 67
 - Green’s function solution, 93
 - ionization, 75
 - lifetime, 87
 - mass estimates, 54
 - molecular line observations, 55
 - nonlinear stability, 103
 - photoevaporation, 134
 - radiative equilibrium, 65
 - ring structure, 56
 - scale height, 58

- disk (cont.)
 - self-gravity, 103, 240
 - effect on vertical structure, 59
 - self-similar solution, 94
 - steady-state solution, 92
 - surface density profile, 4
 - temperature profile, 60, 95
 - time scales
 - cooling, 243
 - observed, 87
 - viscous, 90
 - transition, 56
 - vertical structure, 57–59, 96
 - vortices, 81
 - winds, 127
 - zero-torque boundary condition, 93
- disk instability mode, 246
- disk instability model(, 240
- dispersion dominated encounters, 183, 191
- dispersion relation
 - magnetorotational instability, 111
 - self-gravitating disk, 170
- dissociative recombination, 78
- Doppler method (planet detection), 21
- drag coefficient, 143
- drag law
 - Epstein regime, 142
 - Stokes regime, 143
- dust
 - drift-limited growth, 166
 - emissivity, 66
 - fragmentation-limited growth, 165
 - growth, 145, 153, 160, 162
 - opacity, 71
 - pile-up, 155
 - radial drift, 149
 - settling, 144
 - size distribution, 71
 - sticking efficiency, 162
- dust–gas interaction, 142, 158
- dust–grain collisions, 162
- dwarf planets, 1, 2
- dynamical friction, 202
- eccentric anomaly, 23
- eccentricity, of extrasolar planets, 288
- Einstein ring, 32
- emissivity (of dust), 66
- epicyclic frequency, 170
- Epstein drag, 142
- extrasolar planets
 - 16 Cyg B, 275
 - detection methods, 18–34
 - eccentricity distribution, 288
 - GJ 876, 270
 - habitability, 44
 - scattering, 280
- feeding zone, 193
- fragmentation
 - cooling-driven, 242
- gas disk, 105, 240
- infall-driven, 245
- limit on particle size, 165
- particle disks, 166
- planetesimals, 186
- friction time (dust particles), 144
- gap depth, 260–261
- gap formation, 258–260
- gas drag (on planetesimals), 203
- giant planets
 - gravity field, 238
 - interior structure, 237
 - Gibbs free energy, 73
 - Goldreich–Ward mechanism, 166
 - Grand Tack model (for the inner Solar System), 292
 - gravitational focusing, 182–183
 - gravitational instability
 - giant planet formation, 240
 - planetesimal formation, 172
 - tidal downsizing, 246
 - gravitational lensing, 32
 - gravitational moments (giant planets), 238
 - gravity dominated regime (in planetesimal collisions), 187
 - great inequality (between Jupiter and Saturn), 4
 - habitability, 44
 - Hamiltonian dynamics, 316
 - headwind regime (of pebble accretion), 213
 - high eccentricity migration, 275
 - Hill sphere, 183, 185
 - Hill stability, 282–286
 - Hill surfaces, 283
 - Hill's equations, 185
 - horseshoe orbits, 185, 253
 - hydrostatic equilibrium
 - disk vertical structure, 57
 - giant planets, 226
 - ice giants, 2
 - ice line, 14, 83
 - ideal magnetohydrodynamics, 110
 - induction equation, 110
 - inelastic collisions, 204
 - ionization
 - nonthermal, 76
 - thermal, 75
 - isochron diagram, 11
 - isolation mass, 197–198, 225
 - isotope dating, 9
 - Jacobi constant, 283
 - Jeans escape, 222
 - JUNO constraints (on Jovian structure, 239
 - Jupiter, interior structure models, 239
 - Kelvin–Helmholtz instability, 175
 - Kelvin–Helmholtz time scale (giant planets), 236

- Kepler's equation, 23
- Keplerian orbital velocity, 21
- Kida vortex solution, 81
- kinematic viscosity, 89
- Kirkwood gaps, 6
- Kozai–Lidov dynamics, 272–275
- Kuiper Belt Objects (KBOs), 7
 - resonant capture of, 290
 - total mass, 6
- Lagrange stability, 285
- Late Heavy Bombardment, 292
- layered accretion disk model, 115–117
- lead–lead dating, 12
- leapfrog scheme, 315
- Ledoux criterion, 228
- libration (of resonant argument), 269
- Lindblad resonances, 252
- magnetic braking, 127
- magnetic dynamo, 113
- magnetic fields
 - diffusivity, 114
 - disk winds, 127
 - instabilities, 109
 - magnetohydrodynamics (MHD), 109
 - non-ideal MHD, 114
 - protostellar, 137
- magnetic torque, 127
- magnetorotational instability, 109
- magnetospheric accretion, 137–140
- Maxwell stress, 114
- mean anomaly, 268
- mean longitude, 268
- mean motion, 267
- meteorites, 16
- microlensing, 32
- migration
 - eccentricity damping/growth, 264
 - gas disk, 248–265
 - high eccentricity tidal, 275
 - maps, 261
 - particles, 149
 - planetesimal disks, 276
 - rate, Type 2, 262
 - simulations, 258
 - Solar System evidence for, 290
 - stopping mechanism, 140
 - torque, 249
 - torque formulae, 255
 - Type 1, 257
 - Type 2, 257
- minimum mass Solar Nebula, 4
- molecular cloud cores, 49
- molecular viscosity, 99
- momentum equation, 60
- N-body problem, 311
 - leapfrog, 315
 - softening, 314
 - symplectic transformations, 316
- Neptune, 2
 - migration of, 290
- Newtonian dynamics, 311
- Nice model (for the outer Solar System), 291
- oligarchic growth, 206, 217
- opacity
 - analytic approximations, 72
 - giant planet envelopes, 232
 - Rosseland mean, 71
 - sources within disks, 71
- orderly growth, 208
- overlap (of resonances), 270
- particle pileup, 155
- particle-in-box model (of planetary growth), 190–193
- passive disk, 60
- Pb–Pb dating, 12
- pebble accretion, 210–217
 - accretion rates, 216
 - headwind (or Bondi) regime, 213
 - headwind speed, 212
 - lower mass limit, 214
 - shear (or Hill) regime, 213
 - transition mass (from headwind to shear regime), 215
- pendulum model (of resonance), 269
- photoevaporation, 134
- photoionization cross-section, 77
- Planck function, 20
- planet migration, *see* migration
- planet traps, 261
- planetary satellites, 9
- planetesimals
 - collisions, 186
 - definition, 141
 - distribution of orbital elements, 190
 - formation of, 178
 - formation via gravitational instability, 172–173
 - gravitational collapse, 166
 - growth rates, 192
 - strength, 188
 - velocity dispersion, 198–205
- planets
 - definition, 1
 - habitability, 44
 - interior structure, 237
 - pulsar, 18
 - Solar System properties, 2
- Pluto, 2
 - capture into resonance of, 290
- Poisson equation, 167
- protoplanetary disk, *see* disk
- Q parameter (disk stability), 104, 167–171, 240
- radial drift (of solid particles), 149
- radial velocity method, 21–26
 - biases, 23
 - eccentric orbits, 23
 - noise sources, 24

- radiative diffusion, 226
- radiative temperature gradient, 226
- radioactive dating, 9
 - lead–lead system, 12
 - short-lived radionuclides, 13
- ratio–ratio plot, 11
- Rayleigh criterion (spatial resolution), 20
- Rayleigh criterion (stability of shear flows), 103
- Rayleigh distribution, 190
- recombination, 78
- resonances, 3, 265–270
 - capture, 270–271, 290
 - extrasolar planets, 270
 - Kozai, 272
 - Laplace, 9, 270
 - libration time scale, 269
 - Lindblad, 252
 - mean motion, 4, 267
 - overlap, 270, 285
 - pendulum model, 269
 - resonant argument, 268
 - saturation, 264
 - secondary, 269
 - secular, 269, 272
 - three-body, 269
 - torque transfer, 251
 - width, 269
- restricted three-body problem, 282–283
- Reynolds number, 99
 - magnetic, 116
- Reynolds stress, 114
- Richardson number, 175
- Roche lobe, 185
- Rossby wave instability, 108
- Rosseland mean opacity, 71
- Rossiter–McLaughlin effect, 30
- rotation (T Tauri stars), 138
- rubble pile, 186
- runaway growth (of giant planets), 230
- runaway growth (of protoplanets), 192, 217
- Saha equation, 75
- satellites, 9
- scale height, 58
- scattering (of giant planets), 280
- Schmidt number, 157
- Schwarzschild criterion (convective stability), 228
- secular chaos, 276
- secular dynamics, 275–276
- self-gravitating disk, *see* disk, self-gravity
- settling (of dust), 144
- Shakura–Sunyaev α -prescription, 98–100
- shear dominated encounters, 183, 193
- shear regime (of pebble accretion), 213
- shot noise, 25–26
- silicates, 72, 73
- snow line, 14–16
- softening (in N-body problem), 314
- Solar Nebula, 4
- sound speed, 58
- spectral energy distribution (SED), 69–70
- spiral arms, 243
- stability (of planetary systems), 281–286
- Stokes drag, 143
- stopping time, *see* friction time
- streaming instability, 176
- strength dominated regime (in planetesimal collisions), 187
- symplectic integration, 316
- T Tauri stars, 77
 - accretion rates, 52
 - classification, 51
- terrestrial planets, formation, 181–219
- thermal time scale (giant planet envelopes), 236
- three-body dynamics, 183
- three-body problem, 282
- Tisserand sphere, 185
- Titius–Bode law, 289
- Toomre Q parameter, 104, 167–171, 240
- torque
 - calculation in impulse approximation, 248
 - formulae, 255
 - horseshoe drag, 254
 - Lindblad, 251
 - linear co-rotation, 254
 - resonant, 251
 - thermal torque, 255
- transition disks, 56
- transits, 27–32
 - secondary eclipse, 30
- transmission spectroscopy, 31
- tree codes, 312
- Trojan asteroids, origin of, 292
- true anomaly, 23
- turbulence
 - effect on particle settling, 147
 - effect on terrestrial planet formation, 205
 - hydrodynamic linear stability, 102
 - hydrodynamic sources of, 102
 - magnetic field instabilities, 109
 - phenomenological description of, 99
 - radial diffusion, 156
 - self-gravitating, 102, 241
- ultraviolet radiation, 134
- viscosity, 90, 98, 102–114
 - molecular, 99
- viscous stirring (of planetesimals), 199
- vortensity, 108
- vortices, 81, 107
 - Rossby wave instability, 108
- water delivery (to Earth), 15
- X-ray ionization, 77
- Young Stellar Objects
 - accretion rates, 52
 - classification, 51
 - disk masses, 54
- zero-velocity surfaces, 283
- zonal flows, 80