

Cambridge University Press

978-0-521-85714-7 - Cosmic Catastrophes: Exploding Stars, Black Holes, and Mapping the Universe, Second Edition

J. Craig Wheeler

Index

[More information](#)*Index*

- ADAF, *see* accretion flow, advection-dominated
- ADIOS, *see* advection-dominated inflow-outflow solutions
- Abbott, Edwin, 298, 309
- Abramowicz, Marek, 66
- accretion, 148
- accretion disk, 55–67, 69, 70, 110, 158, 160–2, 215–17, 218, 223, 253
- accretion disk thermal instability, 63–5, 71, 162–3, 165, 166, 216
- accretion flow, advection-dominated (ADAF), 65–7
- convection-dominated (CDAF), 67
- magnetically-dominated (MDAF), 67
- accretion induced collapse, 169
- active galactic nuclei, 221, 253
- active galaxies, 223, 244
- Advanced X-ray Astronomy Facility*, *see* *Chandra X-ray Observatory*
- advection, 65
- advection-dominated accretion flow (ADAF), *see* accretion flow, advection-dominated
- advection-dominated inflow-outflow solutions (ADIOS), 67
- afterglow, 236–7, 239, 241, 242, 245, 246, 247, 250, 251, 256, 258, 262
- age of the Universe, *see* Universe, age of
- Akerlof, Carl 237–8
- Akiyama, Shizuka, 97–8
- Algol, 46–7, 50
- Algol paradox, 46–7
- Alpha Centauri, 30, 210
- American Astronomical Society, 238
- Anderson, Carl David, 8
- Andromeda galaxy, 124, 225, 228, 257, 263
- Anglo-Australian Observatory, 127
- angular momentum, 6, 43, 44, 48, 49, 53, 56–8, 60, 77, 101, 152, 162, 168, 198
- conservation of, 6, 48, 49, 56, 151
- annihilation, of electrons, 113
- of matter, 236
- of particles, 283
- anomalous X-ray pulsars, 173
- anthropic principle, 297
- anti-de Sitter space, 325
- antielectrons, 8
- antigravity, 10, 280, 281, 282, 283, 284, 285, 288, 292
- antimatter, 8, 29, 65, 195
- antineutrinos, 8, 25
- antineutron, 8, 199
- antineutron star, 199
- antiparticles, 8, 9
- antiphoton, 196
- antiproton, 8, 9, 322
- AO620-00, 212–14, 216
- argon, 23, 32
- arrow of time, 286
- asteroid, 120, 174, 197, 233, 277, 300
- astres occlus, 177
- atomic nuclei, 86
- Australia, 120
- axis, magnetic, 252
- spin, 138, 145, 146, 152, 161, 202, 252
- axis of rotation, *see* axis, spin
- Baade, Dietrich, 96
- Babylon 5*, 292
- Back to the Future*, 295
- Balbus, Steve, 59
- bar magnet, *see* pole, magnetic
- bare core, 159–60
- Barkat, Zalman, 260
- Barthelmy, Scott, 235
- baryon, 7, 8, 9, 21, 40, 141, 148, 199, 238, 270–1, 281, 285
- conservation of, 8
- baryon number, *see* baryon

Cambridge University Press

978-0-521-85714-7 - Cosmic Catastrophes: Exploding Stars, Black Holes, and Mapping the Universe, Second Edition

J. Craig Wheeler

Index

[More information](#)

Index

329

- baryonic matter, *see* baryon
- beaming, 134, 241, 242
- Begelman, Mitch, 67
- Bell, Jocelyn, 142–3
- BeppoSAX*, 233–7, 241, 247, 251, 256, 258
- Betelgeuse, 115–17, 175
- big bang, 8, 87, 197, 266, 271, 288, 296, 303, 306, 321, 324
- big crunch, 285
- big rip, 285
- Bignami, Giovanni, 174
- binary, close, 47, 50
- wide, 42
- binary black holes, *see* black hole, in binary
- binary evolution, *see* binary stars
- binary orbit, *see* binary stars
- binary pulsars, 152–6
- binary star evolution, *see* binary stars
- binary stars, 42–54, 55, 56, 69, 107, 153, 155, 168–9, 221, 222, 262
- binary system, *see* binary stars
- binding energy, nuclear, 103
- biocomplexity, 117
- biological clock, 193–4
- black hole, 1, 4, 41, 50, 52–3, 61, 65–6, 81, 90–1, 98–9, 101, 105, 133, 141, 148, 161, 176–206, 207–28, 229, 232, 252–3, 254
- in binary, 69, 97
- no hair, 199, 298, 315
- rotating, 201–202, 204, 205, 208
- Schwarzschild, 200–1, 287
- supermassive, 66, 208, 221, 223–8, 253, 261
- time, 193–5
- black hole evaporation, 195–8
- black hole X-ray nova, 213–15, 217–19, 222
- Black Holes and Time Warps: Einstein's Outrageous Legacy*, 287
- Black Widow system, 168
- Blandford, Roger, 167
- blast wave, relativistic, 237, 247–8
- blazar, 242, 244
- Bloom, Josh, 249
- blue sheet, 206, 287
- blue shift, 139, 206, 219, 241, 245
- blue supergiant, 30, 130, 133, 134, 136, 260, 261
- bomb, thermonuclear, 19
- bomb tests, nuclear, 229
- bow shocks, 99
- bow wave, 91, 98
- Brahe, Tycho, 44, 80, 118
- brane worlds, 317–22
- brightness-decline relationship, *see* supernova, brightness-decline relationship
- Bromm, Volker, 226, 260
- bulge, galactic, 228
- bulk, 319–20
- burning, nuclear, *see* thermonuclear burning
- thermonuclear burning, 17–22, 28–30, 72, 86
- subsonic, 105
- supersonic, 105
- Burst and Transient Source Experiment (BATSE), 231, 233, 235, 255, 262
- bursting pulsar, 166
- CDAF, *see* accretion flow, convection-dominated
- calcium, 32, 84, 103–10, 139
- high-velocity, 110–11
- calculus, 180, 272
- Caldwell, Robert, 285
- Calgalleon, 118, 127
- Calabi-Yau space, 318, 320
- calibrated candle, 273–5
- carbon, 31–2, 36, 72, 76, 84–8, 90, 103–4, 105, 107, 156, 260
- carbon burning, 78, 86, 104, 105–14
- carbon density, 78
- carbon ignition, 104
- carbon monoxide, 139
- Cassini* spacecraft, 178
- Cassiopeia A, 80–1, 94–5, 133, 148
- cataclysmic variable, 69–72, 74, 76, 77, 108
- Centaurus X-3, 160–2, 163
- Centaurus X-4, 165
- Center for Astronomical Telegrams, 124
- center of the Galaxy, *see* Galactic center
- center of mass, 43–4
- centrifugal force, 100, 167, 171, 202
- Cerenkov radiation, 24
- Chandler, Jeff, 126
- Chandra X-ray Observatory*, 16, 81–2, 94, 134, 157, 223, 231
- Chandrasekhar, Subramanyan, 15, 141
- Chandrasekhar limit, *see* Chandrasekhar mass
- Chandrasekhar mass, 15, 76, 103, 104, 108–10, 153
- Chandrasekhar mass limit, *see* Chandrasekhar mass
- charge, conservation of, 6, 8
- electrical, 6–23, 28, 198, 270, 315, 317
- charge repulsion, 28, 31–2
- Chinese guest star, 79

Cambridge University Press

978-0-521-85714-7 - Cosmic Catastrophes: Exploding Stars, Black Holes, and Mapping the Universe, Second Edition

J. Craig Wheeler

Index

[More information](#)

330 Index

- Chinese historical records, 79, 80
 chlorine, 23–5
 Choptuik, Matt, 201
 chromosomal damage, 116
 Chu, You-Hua, 129–30
 circumference, 187, 188, 192, 277
 classical nova, *see* nova, classical
 cluster, stellar, 86, 88, 97, 259
 cluster of galaxies, 118, 120, 256
 cobalt-56, 113–14, 134, 135, 138
 Colgate, Stirling, 229–30, 275–6
 collapsar, 253
 comets, 32, 232, 233
 common envelope, 52–4, 74, 101, 109, 159, 220, 254
 compact space, 312
 Compton, Arthur Holly, 217, 231
Compton Gamma Ray Observatory, 166, 174, 217, 231
 Compton scattering, 217
 concordance model, 281
 conservation laws, 4–10
 conservation of angular momentum, *see* angular momentum, conservation of
 conservation of baryons, *see* baryons, conservation of
 conservation of charge, *see* charge, conservation of
 conservation of energy, *see* energy, conservation of
 conservation of leptons, *see* leptons, conservation of
 conservation of momentum, *see* linear momentum, conservation of
Contact (movie), 287
Contact (novel), 292
 Conti, Peter, 128
 convection-dominated accretion flow, *see* accretion flow, convection-dominated
 Coonabarabran, 127
 core bounce, 90–1
 core collapse, 34, 37–9, 41, 82, 85, 86, 90, 93–4, 96, 97, 98, 100, 101, 104, 211, 245
 core, carbon/oxygen, 109, 244, 249
 helium, 10–21, 28, 50, 90
 iron, *see* iron core
 oxygen, 261
 oxygen/neon/magnesium, 86, 156
 stellar, 1, 10–21, 28–30, 34, 52, 130–2, 261
 corona, 216, 217
corps obscur, 177, 179
Cosmic Background Explorer (COBE), 271, 304
 cosmic background radiation, 259, 266, 269, 271, 325
 cosmic censorship, 201
 cosmic rays, 117, 322
 cosmological constant, 272–3, 278–80
 cosmology, 262, 263, 275–7, 288, 324
 Crab nebula, 79, 81, 133–4, 142, 144, 147, 148
 Crab nebula pulsar, 94, 144, 167–8, 174
 Cronkite, Walter, 219
 Crucifixion (Corpus Hypercubus), 309
 crust, neutron star, 149–52, 171–3
 cubism, 309
 curvature of the Universe, *see* Universe, curvature of
 curved space, 54, 179, 180, 183–93, 289
 Cygnus X-1, 209–14, 227
 30 Doradus, 120
 Dali, Salvadore, 309
 dark ages, 226, 259, 260–2, 271
 dark energy, 281–5, 288, 306, 321
 dark matter, 270–2, 279, 280, 282, 285
 Davis, Raymond, 21, 25
 death line, 170
 death valley, 170
Deep Space 9, *see* *Star Trek: Deep Space 9*
 deflagration, 105–7, 114
 deflagration-to-detonation models, 105–7
 deflection of light, 178, 301
 density, 35–6, 40, 63, 65, 72, 76, 78, 88, 101, 104, 114, 139, 182, 271
 detonation, 105–8, 114
 dipole field, *see* magnetic field, dipole
 disk-heating instability, *see* accretion disk thermal instability
 Dopita, Michael, 127
 Doppler shift, 138, 152, 153, 163, 193, 210, 220, 221–5, 268, 278
 drag, 53, 60–1
 duality, 314
 Duhalde, Oscar, 120, 126, 133
 Duncan, Robert, 171–2, 256
 duplicity, 42
 dust, 120, 140, 221, 270
 dwarf star, *see* star, dwarf
 dwarf nova, *see* nova, dwarf
 dynamic equilibrium, 10
 dynamite, 104–5
 dynamo, 61, 67, 144
 $E = mc^2$, 4, 5, 9, 19, 153, 176, 204, 270, 288
 Earth, 8, 24, 26, 32, 36, 46, 58, 60, 68–9, 78, 113–17, 119, 120, 132,

Cambridge University Press

978-0-521-85714-7 - Cosmic Catastrophes: Exploding Stars, Black Holes, and Mapping the Universe, Second Edition

J. Craig Wheeler

Index

[More information](#)

Index

331

- 133, 134, 145, 147, 149, 155, 160,
161, 170, 172, 173, 174, 175,
178–80, 181, 182, 184, 189, 192,
199, 220, 229, 230, 231, 236, 240
- Earth atmosphere, 156
- Earth ionosphere, 172, 173
- Earth orbit, 36, 78–112, 116, 174
- eclipse, 47, 153, 155, 157
- Eddington, Sir Arthur, 35
- Eddington limit luminosity, 35, 53,
164–5, 223, 226, 227, 228, 232
- Eddington mass accretion rate, 35
- Einstein, Albert, 4, 9, 43, 119, 154,
178, 181, 183, 200, 263
- Einstein's equations, 176, 283, 287
- Einstein's theory of gravity, *see*
gravity, Einstein's theory of
- Einstein's theory of general relativity,
see gravity, Einstein's theory of
- Einstein-Rosen bridge, 287–8
- Einstein*, 157
- Einstein satellite 174
- Ekpyrotic theory, 320
- electric field, 94, 96, 144
- electrical charge, *see* charge, electrical
- electrical force, *see* force, electrical
- electromagnetic force, *see* force,
electromagnetic
- electromagnetic radiation, 94, 144,
270, 309, 311, 319
- electromagnetic wave, 94, 300
- electron, 2–3, 7–8, 13, 15, 20–4, 24,
35, 37, 39, 40, 65, 68, 86, 113,
116, 141, 146, 147, 149–69, 195
- electron capture, 169
- electron/positron pairs, 146
- electroweak force, *see* force,
electroweak
- ellipse, 43, 44, 138
- elliptical galaxy, 102, 108, 118–19,
120, 256
- embedding diagram, 185–7, 264, 289,
306, 308
- emergent properties, 327
- emission lines, 128, 216, 219
- energy, 5–11, 13–19, 21, 24–5, 27–8,
30–3, 35–6, 39, 41, 51–8, 60–1,
65, 66, 71, 74, 90, 98, 100, 105,
112, 114–16, 134, 138, 141, 143,
153, 160, 170, 173, 176, 195, 196,
197, 199
- accretion, 253
- conservation of, 5, 8, 10, 11–19, 27,
53, 51–8, 60, 154
- gravitational, 5, 35–41, 51, 66, 150
- heat, 28, 39, 148, 214–15, 218
- negative, 288
- neutrinos, 116, 132
- nuclear, 16, 17, 103, 113
- orbital, 101
- quantum, 15, 76, 149
- radiation, 32, 33
- rotation, 67, 81, 87, 97, 101, 102,
143, 145, 155, 169
- shock, 112, 114, 134
- thermal, 10, 15, 76, 150
- vacuum, *see* vacuum energy
- energy density, 280, 282
- Enterprise*, 290
- entropy, 315, 323–4
- envelope, common, *see* common
envelope
- helium 96
- hydrogen, 34, 84, 85, 90–116, 98,
99, 102, 109–10, 166, 260
- red giant, 34, 36, 53, 74, 81, 83, 159
- stellar, 28, 30, 31, 36, 37, 38, 53, 81,
84
- equator, 99, 100, 136, 139, 151, 171,
202, 204, 252
- equivalence principle, 301
- ergosphere, 202
- escape velocity, 177
- Euclid, 185
- European Southern Observatory, 96
- event horizon, 179–81, 193, 194,
195–6, 198, 199, 200, 201–6, 211,
216, 225, 287
- evolution, stellar, 130
- exclusion principle, 15, 149
- excretion disk, 51, 74
- exotic matter, 287, 292
- expanding universe, 261–2
- explosion, thermonuclear, 70, 72,
104, 112, 162, 105
- Far East, 79
- Fermi, Enrico, 20
- fission, nuclear, 39
- flame, 105
- Flamsteed, John, 81
- flat space, 184–5, 189, 200, 290, 325
- Flatland*, 298–9, 309
- fluctuation, 324
- force, electrical, 19, 28, 317, 318
- electromagnetic, 38, 311, 324
- electroweak, 3, 4, 320
- magnetic, 3, 61, 145, 161
- nuclear, 2, 19, 28, 31, 37, 40, 88,
113, 149, 182, 270, 285, 311,
319, 320
- strong, *see* force, nuclear
- weak, 2, 4, 20, 21, 112, 113
- force of gravity, 4, 40, 43–4, 178, 180,
300, 310

Cambridge University Press

978-0-521-85714-7 - Cosmic Catastrophes: Exploding Stars, Black Holes, and Mapping the Universe, Second Edition

J. Craig Wheeler

Index

[More information](#)

332 Index

- Frail, Dale, 247
 free fall, 179
 free will, 293–5
 frequency of light, 193, 152
 frequency of pulses, 152, 166
 friction, 53, 58–9, 61, 158
 frozen star, 194
 fuel, thermonuclear, 28, 71
 fusion, thermonuclear, 20, 22
- galactic bulge, *see* bulge, galactic
 Galactic center, 173, 221, 224, 231
 Galaxy, Milky Way, 17, 68, 69, 79, 80,
 82–91, 85, 86, 88, 96, 108, 111,
 115, 118, 125, 170, 207, 210, 212,
 223, 224, 227
 galaxy, elliptical, 83, 102, 120, 256
 irregular, 102, 118–19, 120
 spiral, 83, 102–20, 228, 257
Galileo spacecraft, 178
 Galileo (Galilei), 80
 gallium, 25
 Gamezo, Vadim, 107
 gamma rays, 66, 113–14, 117, 127,
 135, 147–72, 170, 174, 213–14
 gamma-ray burst, 170, 172, 317, 229–62
 gamma-ray burst afterglow,
 see afterglow
 gas, interstellar, 89, 147, 220, 224,
 236, 237, 261, 307
 Gebhardt, Karl, 225, 227
 Geminga, 174–5
 Gemini telescopes, 237
 general relativity, *see* gravity,
 Einstein's theory of
 Genzel, Reinhardt, 224
 Gerardy, Chris, 110
 Ghez, Andrea 224
 Giacconi, Riccardo, 156
Ginga, 125
 Glashow, Sheldon, 2
 glitches, 150–2, 171
 global positioning systems, 178
 globular cluster, 163, 165, 227–8
 gluons, 311
 Gnarrangaleon, 118, 127
 Goddard Space Flight Center, 235
 Gott, James, 307
 Grand Unified Theory, 4, 8, 31
 grandfather paradox, 293
 graphite, 140
 Graves, Jenny, 134
 gravitational collapse, 148, 154, 244
 gravitational constant, Newton's, *see*
 Newton's constant
 gravitation deceleration, 263
 gravitational energy, *see* energy,
 gravitational
 gravitational force, *see* force of gravity
 gravitational radiation, 54, 77, 78,
 153, 154, 155, 226, 262
 gravitational waves, 54, 77, 103, 250,
 257, 321
 gravitons, 319
 gravity, 1–10, 14, 16, 28, 30, 31, 34,
 35, 38, 39, 40, 43, 44, 46, 52, 53,
 54–60, 65, 77, 79, 80, 98, 100,
 111, 135, 143, 148, 154, 157, 160,
 170–2, 178
 Einstein's theory of, 4, 154, 176,
 178, 179, 181, 183, 189–93, 194,
 195, 222, 269, 272, 279, 293, 297,
 310, 315, 316, 325
 Newton's theory of, 44, 177, 178,
 189, 262, 300–1, 310, 313, 321,
 GRB 970228, 234, 250
 GRB 970508, 234
 GRB 971214, 234, 235, 236, 241, 250
 GRB 980425, 247–8
 GRB 990123, 235, 236, 238, 241, 245
 GRB 021004, 250
 GRB 030329, 250
 Green, Brian, 311
 GRO J1744–28, 166
- halo, 227
 half-life, 114, 135
 Hamuy, Mario, 110
 Harkness, Robert, 125–6
 Hawking, Stephen, 195–316, 201,
 201, 315, 321, 323
 Hawking radiation, 195, 198, 270,
 283, 285, 295, 315
 Hawley, John, 59
 heavy elements, 1, 24, 27, 76, 86–8,
 103, 120, 211, 260, 307
 Heisenberg, Werner, 295
 Heisenberg uncertainty principle, *see*
 Uncertainty Principle
 helium, 19–21, 20, 21–4, 27, 28, 30,
 31, 32, 36–7, 50–1, 69, 84, 85, 86,
 87, 96, 98, 102, 103, 109, 110,
 112, 133, 136
 liquid, 150
 helium burning, 28, 30, 31, 37
 helium core, *see* core, helium
 helium envelope, *see* envelope,
 helium
 helium ignition, *see* helium burning
 helium nuclei, 31, 103
 Henderson, Linda, 308
 Hercules X-1, 158–61, 162, 163
 Hewish, Anthony, 142
High Energy Transient Explorer (HETE 1,
HETE 2), 234, 237, 239, 250–1,
 256–7, 258, 259

Cambridge University Press

978-0-521-85714-7 - Cosmic Catastrophes: Exploding Stars, Black Holes, and Mapping the Universe, Second Edition

J. Craig Wheeler

Index

[More information](#)

Index

333

- Hobby-Eberly Telescope, 237, 239, 250
 Höflich, Peter, 98, 107, 110, 249, 260
 Hogan, Craig 324–5
 holograms, 322–3
 holographic principle, 323
 holographic universe, 322
 Homestake gold mine, 23–4
Homo sapiens, 119
 hot spot, 70, 172, 216
 Hubble, Edwin, 268
 Hubble constant, 268–9, 278, 279, 284
Hubble Space Telescope, 111, 130, 134, 136–8, 166, 174, 216, 224, 276, 277, 283, 324
 Hulse, Russell, 154
 hydrogen, 19–21, 27–8, 30, 32, 34, 46–7, 50, 51, 69, 72, 76, 84, 88, 90–116, 124, 125, 130, 136, 146, 211
 hydrogen bomb, 147
 hydrogen burning, 17, 28
 hydrogen envelope, *see* envelope, hydrogen
 hypernova, 249
 hyperspace, 188–90, 268, 285, 288, 290, 306, 308–11
- ignition, thermonuclear, *see* burning, thermonuclear
 impenetrability, 11
 Industrial Revolution, 119
 infinity, 105, 177, 178, 181, 183, 187, 193, 202, 264, 269, 285, 287, 296
 inflation, 281, 284, 288, 324
 information, 21, 44, 103–4
 information crisis, 315
 information theory, 323
 infrared, 107, 224, 231
International Ultraviolet Explorer, 124, 130
 Internet, 277, 322
 interstellar gas, *see* gas, interstellar
 interstellar matter, medium, *see* gas, interstellar
 inverse-square law, apparent
 brightness, 119, 235, 236, 247
 gravity, 316, 317, 319, 321, 325–6
 iron, 37–41, 50, 76, 84–91, 100–1, 113
 iron-56, 113
 iron core, 39–41, 50, 86, 88, 90, 97, 100, 101, 107, 114–15, 156, 211, 260, 261
 iron oxides, 140
 iron-peak elements, 105
 isotropic equivalent energy, 246
- J037–3039, 155
 jalapeño pepper, 239
- James Webb Space Telescope*, 260
 Japanese, 125
 jet, 67, 82, 93–4, 98–9, 100, 101, 102, 136, 139, 220, 244–5, 251
 jet-induced supernova, *see* supernova, jet-induced
 Jupiter, 44, 133, 178
- Kamioka experiment, 132
 Kamiokande, 24
 Super, 25
 Keck telescopes, 237
 Kenya, 156
 Kepler, Johannes, 44, 80, 118
 Kepler's first law, 44
 Kepler's second law, 44
 Kepler's third law, 44, 47, 57, 153
 Kepler's supernova, *see* supernova 1604
 Kerr, Roy, 201
 Kerr black hole, *see* black hole, rotating
 Khokhlov, Alexei, 98–9, 107
 King Charles II, 81
 Kirshner, Robert, 124
 Klebesadel, Raymond, 230
 Korea, 79
 Kormendy, John, 268
 Kudritzki, Rolf, 128
 Kulkarni, Shrinivas, 247, 249
- L5 Society, 46
 Lagrange, Joseph Louis, Comte, 46
 Lagrangian point, inner, 46, 48, 56
 second, 46
 third, 46
 fourth, 46
 fifth, 46
 Landau, Lev, 141, 150
 LaPlace, Pierre Simon, Marquis de, 177, 179
 Large Magellanic Cloud, 118–20, 127, 211
 Las Campanas Observatory, 120
 last stable circular orbit, 216
 Lawrence Berkeley Laboratory, 276
 Lawrence Livermore National Laboratory, 230, 235
 Lead, South Dakota, 23
 Leo IX, Pope, 80
 lepton, 20, 29, 199
 conservation of, 8, 199
 lepton number, 170, 199
 Lewin, Walter, 125
 light, speed of, 21, 58, 132, 137, 146, 147, 177, 178, 179, 201–4, 220, 221, 222, 230, 232, 237, 238, 240, 242, 245, 247, 287, 300, 304

Cambridge University Press

978-0-521-85714-7 - Cosmic Catastrophes: Exploding Stars, Black Holes, and Mapping the Universe, Second Edition

J. Craig Wheeler

Index

[More information](#)

334 Index

- light curve, dwarf nova, 71
 nova, 70
 supernova, 83, 102–5, 111–16, 129, 241
- light travel time, 143
- light, ultraviolet, *see* radiation, ultraviolet
- lighthouse effect, 145, 161, 163, 166, 172
- Limited Test Ban Treaty, 229
- linear momentum, 43–4
 conservation of, 43–4
- Linde, Andre, 306–8
- lines of magnetic force, 145
- liquid helium, 150
- lithium, 266
- little green men (LGM), 142
- LMC X-3, 211–13
- Lobachevsky, Nikolai Ivanovich, 308
- Local Group, 118
- Los Alamos National Laboratory, 235, 238, 239, 275
- luminosity, 17, 33, 35, 53, 63, 165, 226, 227, 228, 233
 Eddington limit, *see* Eddington limit luminosity
- luminosity of accretion, 35, 57, 162, 164, 166, 169
- luminosity of gamma-ray bursts, 229
- luminosity of supernovae, 107, 108, 111, 249, 273, 274, 275, 279
- Lyne, Andrew, 155
- M theory, 314, 326, 327
- M15, 228
- Magellan, Ferdinand, 118
- Magellanic Clouds, 127
- magnesium, 76, 84, 103–5, 86–8, 156
- magnetar, 171–3, 252, 255–6
- magnetic axis, *see* axis, magnetic
- magnetic field, 59, 61, 65, 87, 97, 135, 144, 149, 152, 155, 159, 161, 162, 164, 165, 166, 167, 169, 170, 171, 172–4, 175, 220, 226, 251, 252, 253, 254, 282
 dipole, 144, 252
- magnetic force, *see* force, magnetic
- magnetic poles, 145, 159, 161, 163, 165, 166, 169, 175
- magnetically-dominated accretion flow (MDAF), *see* accretion flow, magnetically-dominated
- magnetopause, 117
- magnetosphere, 155, 229
- magneto-rotational instability, 61, 67, 90–7
- main sequence, *see* star, main sequence
- Manhattan Project, 20, 141
- many world theory, 326
- Marion, Howie, 107
- Mars, 173
- Martin, Steve, 310
- mass, 5
 mass of particle, 2, 7, 9, 11, 13
 mass of star, 17, 31, 32, 34, 37–9, 46, 83, 84–8, 107, 114, 133, 148, 154, 207, 211, 212, 213–27, 246, 250
- mass transfer, 47–50, 54, 69, 71, 74, 108, 154, 157, 162
- matricide paradox, 293
- matter density, 280, 285
- Maxwell, James Clerk, 3
- McCall, Marshall, 124
- McDonald Observatory, 124, 239, 250
- McNaught, Rob, 120, 133
- MDAF, *see* accretion flow, magnetically-dominated
- Meier, David, 67, 252, 254
- Mercury, 178, 301
- Messier 31, *see* Andromeda galaxy
- Middle Ages, 119
- Middle East, 79
- Milky Way, *see* Galaxy, Milky Way
- millisecond pulsars, 167–70, 171
- mini black holes, 197
- miniquasars, 221–8, 253
- Minkowski, Rudolph, 142, 144
- Mirabel, Felix, 221
- Mitchell, John, 177, 179
- molecules, 139
- momentum, 6, 11–15, 294
- Moon, 46, 160, 173, 180, 182, 189, 192, 229, 232, 276
- Mount Everest, 149
- Mount Stromlo Observatory, 127
- multiple stars, 42–3
- mutations, 117
- MXB 1730–335 165
- mystery spot, 138
- naked singularity, *see* singularity
- Namibia, 239
- Narayan, Ramesh, 66
- Nather, R. Edward, 68
- Native Americans, 79
- natural selection, 307
- nebula, planetary, 37, 53
- negative energy, 288
- negative feedback, 19
- negative pressure, 288
- neon, 76, 86–8
- neutrino, 20–1, 23, 24–5, 32, 40, 41, 76, 90–1, 92–3, 98, 101, 116, 119, 132, 148, 153, 235, 242

Cambridge University Press

978-0-521-85714-7 - Cosmic Catastrophes: Exploding Stars, Black Holes, and Mapping the Universe, Second Edition

J. Craig Wheeler

Index

[More information](#)

Index

335

- sterile, 26
- neutron, 2, 7, 8, 13, 19–23, 24, 25, 28, 31–2, 37–40, 53, 86, 88, 90–1, 112, 139, 141, 148, 149, 150, 182, 199
- neutron drip, 149
- neutron star, 35, 40, 41, 50, 52–4, 56, 58, 76, 81–2, 85–7, 88–102, 132, 133–4, 141–75
- maximum mass, 141
- neutron star crust, *see* crust, neutron star
- Newton, Sir Isaac, 44, 80, 178–9, 189, 300
- Newton's constant, 303, 307
- Newton's theory of gravity, *see* gravity, Newton's theory of
- nickel-56, 113–14, 134, 138, 257, 261, 274
- Nobel Prize, 3, 8, 20, 23, 142, 150, 154, 156, 217, 323,
- noble gas, 23, 150
- noodle effect, 182
- north pole, 144
- nova, 71
- classical, 71–2, 108, 162, 164
- dwarf, 61, 71, 165, 212
- recurrent, 71
- X-ray, *see* black hole X-ray nova
- Nova Muscae 1991, 214
- Novak, Marcos, 309
- Novikov, Igor, 292–5
- Novikov Consistency Conjecture, 294, 308
- nuclear bomb, 229
- nucleosynthesis, 100
- nuclear fission, *see* fission, nuclear
- nuclear force, *see* force, nuclear
- nuclear physics, *see* physics, nuclear
- Occhialini, Giuseppe, 233
- Oda, Minoru, 125
- Olson, Roy, 230
- opacity, 63, 71, 226
- Oppenheimer, Robert, 141
- Oppenheimer-Volkoff limit, 141
- optical radiation, *see* radiation, optical
- Oran, Elaine, 107
- orbit, planetary, 189, 318
- stellar, 43–4, 53–4, 74–6, 153, 158
- orbital period, *see* period, orbital
- orbital plane, 56, 74
- Orion, 115
- Orion nebula, 175
- Ostriker, Jeremiah, 232
- oxygen, 20–24, 31–2, 36, 69, 72, 76, 84, 90, 103–5, 112–13, 126, 156, 260
- oxygen core, *see* core, oxygen
- oxygen/neon/magnesium core, *see* core, oxygen/neon/magnesium
- pair formation supernovae, 261
- Panagia, Nino, 124
- paradox, Algol, *see* Algol paradox
- grandfather, *see* grandfather paradox
- matricide, *see* matricide paradox
- twin, *see* twin paradox
- parallax, 174
- parallel lines, 184, 188
- parallel propagation, 184–5
- Payne-Gaposhkin, Cecelia, 42
- p-branes, 314
- Penrose, Roger, 193, 202
- Penrose process, 204
- period, orbital, 42, 44–5, 221
- Perlmutter, Saul, 276
- photon, 13, 21, 33, 94, 113, 116, 127, 133, 170, 194, 196, 202, 204, 206, 285, 311
- physics, end of, 327
- nuclear, 59
- pi mesons, 311
- Picasso, Pablo, 309
- Picasso at the Lapin Agile*, 310
- Planck area, 323, 324
- Planck density, 303, 306
- Planck length, 303, 323
- Planck mass, 303
- Planck scale, 303, 312, 326
- Planck time, 303
- Planck's constant, 303, 307
- planet, 43–4, 266, 270
- planetary nebula, 37, 53, 242
- plasma, 171, 217
- plateau, supernovae light curve, 111–12, 116
- platinum, 86
- polarization, 93, 110, 138, 244
- Polchinski, Joseph, 294, 314–19
- pole, magnetic, 145
- pool-ball crisis, 294, 319
- pool-ball physics, 294
- positive feedback, 48, 50
- positron, 8–9, 20, 65, 113, 115, 195, 260
- pressure, 10, 15, 16, 19, 33, 35, 36, 39, 43, 65
- pressure, negative, *see* negative pressure
- quantum, 15, 35–6, 37, 39–40, 50, 72, 77–8, 86, 88, 104–5, 109, 141, 164
- radiation, 33, 34, 35, 220, 223, 227, 233

Cambridge University Press

978-0-521-85714-7 - Cosmic Catastrophes: Exploding Stars, Black Holes, and Mapping the Universe, Second Edition

J. Craig Wheeler

Index

[More information](#)

336

Index

- thermal, 15, 16, 35, 39, 50, 77, 86, 109, 211
- proper motion, 174
- proton, 2, 6–23, 28, 31–2, 37, 39, 40, 86, 88, 91, 103, 112–13, 149, 182, 195, 238, 251, 266, 270, 271, 282, 298, 300, 303
- protostar, 16–17, 97, 242
- Proxima Centauri, 42
- pulsar, 94, 148, 151, 155, 161, 166–74, 252
- anomalous X-ray, 173
- binary, 152–6, 159, 160
- Crab nebula, 79, 81, 94, 144, 147–72
- death line, 170
- death valley, 170
- millisecond, 167–70
- radio, 152, 155, 161, 167, 169, 173
- X-ray, 146–73, 147, 163–6, 174
- radiation pressure, *see* pressure, radiation
- radio communications, 170, 172
- radioactive decay, 111–14, 116, 127, 134, 138, 274,
- radioactive nickel, 111–17
- Randall, Lisa, 319
- Rapid Burster, 165–70
- reactions, nuclear, 24, 112
- red giant, 27–32, 34, 36, 47, 50, 51, 53–4, 72, 74, 83–4, 103, 109, 112, 115, 130, 136, 220
- red shift, 138, 194, 219, 235, 241, 258, 266, 268, 279, 280
- infinite surface of, 200–5
- red supergiant, 130, 260, 261
- Rees, Sir Martin, 222
- Reichart, Dan, 250
- Reimann, Georg, 308
- Reines, Fred, 20
- Riess, Adam, 283
- relativistic blast wave, *see* blast wave, relativistic
- relativity, general theory of, *see* gravity, Einstein's theory of
- Einstein's special theory of, 201, 220, 240, 300
- Renaissance, 120
- rings around SN 1987A, 118–40
- ring singularity, *see* singularity, ring
- Robotic Optical Transient Search Experiment (ROTSE)*, 235–9
- Roche lobe, 51, 56, 74, 77, 110, 159, 160
- Rodriguez, Luis, 221
- Röntgen Astronomy Satellite (ROSAT)*, 174, 216
- Rossi, Bruno, 166
- Rossi X-ray Timing Explorer (RXTE)*, 166, 172
- rotation, 69, 87, 96–7, 101, 102, 143, 146, 155, 165
- rotation axis, *see* axis, spin
- rotation of black hole, 201–4, 208
- rotation of neutron star, 81–7, 97, 98, 101, 144, 146–73, 162, 171, 172
- rotation of perihelion, 178
- rotation of white dwarf, 144
- Rubbia, Carlo, 2
- Ruderman, Malvin, 170, 232
- Ruiz-Lapuente, Pilar, 111
- runaway, thermonuclear, 104
- rust, *see* iron oxides
- Saturn, 178
- Sagan, Carl, 286–9
- Sagittarius A, 224
- Salaam, Abdus, 2
- Qantas Airlines, 126–7
- quantum deregulation, 35–7
- quantum energy, *see* energy, quantum
- quantum fields, 283, 316
- quantum fluctuations, 271, 304, 324
- quantum foam, 304–8
- quantum gravity, 179, 296, 298–302, 316, 326–7
- quantum pressure, *see* pressure, quantum
- quantum theory, 11–16, 119, 181, 195, 301
- quantum uncertainty, 13, 113, 272, 302–3, 312, 324
- quarks, 25, 182, 298, 312
- quasar, 142, 204, 206, 220–3, 226, 236, 242
- quintessence, 284
- radiation, 27
- continuum, 152
- electromagnetic, *see* electromagnetic radiation
- gamma ray, *see* gamma rays
- gravitational, *see* gravitational radiation
- optical, 76, 80, 82, 125, 133, 134, 137, 159, 160, 174, 212, 216, 221, 224, 231, 235, 236, 237, 238
- radio, 80, 144, 147–8, 152, 153, 159, 161, 170, 172, 174, 175, 213, 217, 220, 222, 224–5, 236, 239, 247
- ultraviolet, 58, 116, 129, 159, 204, 216, 233
- X-ray, *see* X-ray radiation

Cambridge University Press

978-0-521-85714-7 - Cosmic Catastrophes: Exploding Stars, Black Holes, and Mapping the Universe, Second Edition

J. Craig Wheeler

Index

[More information](#)

Index

337

- sand, *see* silicon oxides
- Sanduleak, Norman, 128, 219
- satellite, 58–61
- Sato, Katsuhiko, 322
- Schmidt, Brian, 277
- Shelton, Ian, 120, 133
- shear, 97
- Shields, Gregory, 225
- shock front, 91, 105
- shock wave, 90, 91, 109, 112, 114, 116, 132, 147, 229, 237
- short, hard bursts (gamma-ray), 255–7
- silicon, 76, 84, 103–5, 103–10, 105, 112, 113, 156, 249, 260
- silicon monoxide, 139
- silicon oxides, 140
- singularity, 180–2, 193, 196, 200–2, 205, 206, 269, 271, 287, 296, 302–6, 308, 316, 321
- naked, 201
- ring, 205, 312
- theorem, 193
- Sk-69 202, 128–32
- Sliders*, 292
- Small Magellanic Cloud, 118
- Smolin, Lee, 307–8
- soft gamma-ray repeaters, 170–3, 255
- Solar System, 116–18, 168, 172, 232, 298
- solar neutrino problem, 21–6
- solar wind, 32, 118
- South Africa, 124
- south pole, 152
- space, one-dimensional, 4, 185, 298, 314, 315
- two-dimensional, 184–5, 187–9, 289–90, 292, 297, 305
- three-dimensional, 183–5, 187, 188–90, 192, 200, 289–90, 292, 297–9, 308–11, 317–22
- four-dimensional, 188, 190, 319
- ten-dimensional, 298, 314, 317, 320
- Space Infrared Telescope Facility*, 231
- Space Odyssey 2001*, 292
- Space Shuttle Columbia, 239
- special theory of relativity, *see* relativity, Einstein's special theory of
- spectrum, 82
- speed of light, *see* light, speed of
- speed of light circle, 146
- spherical symmetry, 98, 110, 249
- spin, 43, 97, 100, 144, 151, 162
- spin axis, *see* axis, spin
- spiral arms, 83, 85, 102
- spiral galaxy, 69, 118–19, 225, 228, 257
- spiral motion
- Spitzer Space Telescope*, 231
- ss 433, 219–22
- standard candle, 231, 274–5
- star, dwarf, 52
- giant, 115
- main sequence, 17–21, 30, 32, 34, 47, 50, 51, 72, 74–5, 85, 101, 103, 111, 115, 130
- Wolf-Rayet, 34, 84, 85
- Star Trek*, 286, 297, 299, 321
- Star Trek: Deep Space 9*, 292
- Star Trek: The Motion Picture*, 290
- Star Wars*, 321
- Stargate SG-1*, 292
- stationary limit, 202
- Steinhardt, Paul, 284, 320
- stellar evolution, *see* evolution, stellar
- stellar orbits, 43, 44, 53–4, 77–8
- stellar wind, *see* wind, stellar
- Stephenson, C. B., 219
- straight line, 6, 187–9, 312
- string landscape, 327
- string length, 322
- string scale, 312–13, 316
- string theory, 284, 298, 310–16
- strong force, *see* force, nuclear
- Strong, Ian, 230
- subsonic burning, *see* burning, subsonic
- sulfur, 76, 84, 103–5, 110
- Sun 1, 10, 13, 16, 23–5, 27, 30, 31–4, 63, 68, 78, 81, 83, 88, 90, 91, 96, 111, 112, 133, 143, 166, 178, 189, 208, 212, 230, 242
- Sundrum, Raman, 319–20
- Super Kamiokande, *see* Kamiokande, Super
- superfluid, 148–52
- superluminal motion, 222–3
- supermassive black hole, *see* black hole, supermassive
- supernova, 16, 70, 72, 76, 78, 79–114, 115, 133, 141, 147, 148, 168, 175
- brightness-decline relationship, 273–5, 277–9
- historical records, 79–81
- jet-induced, 98–100, 101, 139
- Type I, 82–3, 102, 109
- Type Ia, 83–4, 102–11, 112, 114, 124, 125, 135
- Type Ib, 84, 85, 98, 102, 111–12, 154–5, 244, 248, 254, 260
- Type Ic, 84, 85, 96, 98, 102, 111–12, 154–5, 244, 248, 249, 250, 254, 259, 260
- Type II, 82–3, 84–7, 102–3, 107, 111–12, 114, 115, 124, 133, 134, 244, 248, 260, 262

Cambridge University Press

978-0-521-85714-7 - Cosmic Catastrophes: Exploding Stars, Black Holes, and Mapping the Universe, Second Edition

J. Craig Wheeler

Index

[More information](#)

338 Index

- supernova 1006, 79, 81, 82
 supernova 1054, 79–80, 133
 supernova 1572, 80, 81, 82, 111
 supernova 1604, 80, 82, 118
 supernova 1987A, 81, 82, 118–40, 211, 219
 supernova 1993J, 84, 133
 supernova 1997ef, 248
 supernova 1998bw, 247–50
 supernova remnant, 117, 147, 151, 175, 220
 superradiance, 204
 supersoft X-ray source, *see* X-ray source, supersoft
 supersonic burning, *see* burning, supersonic
 supersymmetry, 325
 surface of infinite red shift, *see* red shift, infinite surface of
 Susskind, Leonard, 323, 327
 Swahili, 156
 Swift satellite, 173, 237, 238, 239, 256, 259, 262
 synchrotron radiation, 220

 't Hooft, Gerardus, 323–4
 Tarantula nebula, 120
 Taylor, Joseph, 154
 telescope, radio, 142, 224–5, 236, 239
 optical, 157, 221, 233, 238
 Teller, Edward, 230
 temperature, 10, 15, 16, 17, 21, 27–8, 30, 32, 36, 37, 58, 63, 72, 76, 105
 surface, 216
 tension, 60
 tesseract, 308
 Terminator, 295
The Elegant Universe, 311
The Fourth Dimension and Non-Euclidean Geometry in Modern Art, 308
The Life of the Cosmos, 307
 theory of everything, 176, 298, 302, 304, 310, 314, 316, 326, 327
 thermal energy, *see* energy, thermal
 thermal pressure, *see* pressure, thermal
 thermonuclear bomb, *see* bomb, thermonuclear
 thermonuclear burning, *see* burning, thermonuclear
 thermonuclear fuel, *see* fuel, thermonuclear
 thermonuclear fusion, *see* fusion, thermonuclear
 thermonuclear explosion, *see* explosion, thermonuclear
 thermonuclear runaway, *see* runaway, thermonuclear

 Thompson, Christopher, 171–2
 Thompson, Sir J.J., 3
 Thorne, Kip, 201, 287–9, 292, 293
 tidal bulge, 182
 tidal force, 182–3, 187, 193, 196, 202, 204, 287, 301, 316
 time, *see* black hole time
 time machine, 206, 262, 286, 292–6, 298, 305, 306, 307
 time-like space, 200, 203, 204
 titanium, 32
 topology, 305
 torque, 101
 torus, 94
 trispatiocentrism, 297–9
trous noirs, 177
 Tsarapkin, Anatoly “Scratchy,” 229–30
 Turkey, 239
 twin paradox, 292–3
 Tycho’s supernova, *see* supernova 1572

 Uhuru satellite, 156–8, 160, 209
 Ultra Luminous X-ray Sources (ULX), 227–8
 ultraviolet light, *see* light, ultraviolet
 Uncertainty Principle, 11, 13, 181, 295, 302
 Universe, acceleration of, 278–81
 age of, 266–9
 curvature of, 269, 278, 281

 V404 Cygni, 214, 215
 vacuum, 8, 53, 74, 202, 206, 270, 272, 279, 282, 284, 288, 295
 vacuum energy, 270, 272–3, 280, 285, 288
 vacuum energy density, *see* vacuum energy
 vacuum fluctuations, 295
 Van Der Meer, Simon, 2–3
 van Paradijs, Jan, 234
 Vela satellites, 229–30
 Vela supernova remnant, 82, 151
 velocity, 6
 Venus, 178
 Very Large Telescope (VLT), 96
 viscosity, 150
 Visser, Matt, 292
 vortices, 152

 Wang, Lifan, 95–6, 138, 242, 244, 249
 Warner, Brian, 124, 126
 weak nuclear force, *see* force, weak
 Weinberg, Steven, 2–3, 283
 Wells, H. G., 286
 Wheeler, Edward, 127
 Wheeler, John Archibald, 142, 195, 199, 287, 304, 315, 327

Cambridge University Press

978-0-521-85714-7 - Cosmic Catastrophes: Exploding Stars, Black Holes, and Mapping the Universe, Second Edition

J. Craig Wheeler

Index

[More information](#)

Index 339

- white dwarf, 15–16, 35, 37, 50, 52, 58, 61, 68–78, 86, 104–5, 106, 107, 108, 109, 111, 141, 143, 149, 153, 154, 160, 162, 209, 257, 262, 274
 carbon/oxygen, 104, 105–14
 merging, 77, 108–11
 white dwarf seismology, 68
 white holes, 197–8
 Whole Earth Telescope, 68–9
Wilkinson Microwave Anisotropy Probe (WMAP), 271, 281, 304, 324
 Wilson, Jim, 252, 254
 wind, stellar, 32–5, 84, 85, 160, 210, 211, 246, 250, 251, 260
 Winget, Donald, 68, 124
 Witten, Ed, 314
 Wolf-Rayet star, *see* star, Wolf-Rayet
 Woosley, Stanford, 252
 World Wide Web, 69
 wormhole, 287, 288, 289–90, 292, 293, 294–6, 298, 305, 316, 325, 326
XMM-Newton X-ray Observatory, 223
 X-ray, 58, 66, 81–2, 109, 125, 135, 137, 147, 156–61, 162–6, 170, 174
 X-ray astronomy, 156–7
 X-ray burst, 163–6, 212, 230
 X-ray flares, 162–4
 X-ray flashes, 258–9, 262
 X-ray nova, *see* black hole X-ray nova
 X-ray pulsar, *see* pulsar, X-ray
 X-ray source, supersoft, 109
 X-ray transient, 61, 162–3, 165
 X-ray radiation, 55, 58, 66, 138, 147, 168–9, 215–16, 217
 Yi, Insu, 66
 Zwicky, Fritz, 82, 141