

Index

- $SL(2, \mathbb{C})$, 209–17
 construction of Minkowski spacetime, 210
 $SU(2)$, 80–2, 111, 178, 179, 207–9, 211, 212
- Absolute time and space, 32
absorber theory, Wheeler–Feynman, 122, 193
Afanassjewa–Jauch Theorem, 149, 155, 157, 160
analytic truth, 25, 105–8, 110, 113
antisymplectic transformations, 67–70, 73, 110, 203
antiunitary operators, 74–9, 82
Aristotle, 65
arrows that misfire
 boundary conditions, 119, 120, 122–4, 126–9, 133
 heuristic, 119, 121, 122, 124, 125, 135, 137, 141, 162
 missing information, 119, 125, 126, 134, 135
asymmetry of counterfactual dependence, 137
atomism, 10, 56, 65
- Bach’s canons, 19, 220
baryogenesis, 129, 130, 190
Berlioz, Hector, 32
big bang, 121, 123, 127–30
Biot, Jean-Baptiste, 7
black holes, 42, 128, 140
Bošković, Ruder, 10, 56, 65
Boltzmann, Ludwig, 11–13
Born rule, 74, 130–2
Boyle, Robert, 10, 56, 65
Bridgman, Percy, 22, 23
- C violation, 17, 18, 129, 185
caloric, 8
Carathéodory’s principle, 148–50
Carnot cycle, 8
Carnot, Sadi, 7–10
 Carnot cycle, 7–9
category, 47, 52
- causality, 2, 33, 116, 136, 168
charge conjugation, 17, 18, 129, 178, 193, 194, 198, 199, 202–6, 208, 209, 211–18
classical field theory, 201–3, 205
Clausius inequality, 145, 155–9
collapse theories, 131–3
constraint approach, thermodynamic, 153–5, 166
constructive relativity, 33, 106, 170
contact manifold, 150, 151
contact structure, 150, 151
cosmological arrow, 126–30, 190
counting argument, 11, 143
covering map, 209–11, 213
CP violation, 18, 19, 96, 129, 179–85
CPT symmetry, viii, 17, 19, 46, 51, 96, 97, 123, 129, 135, 178, 181, 183–5, 190, 191, 193–6, 199, 200, 204, 205, 215, 217, 218
Cronin, James, 17–19, 179, 180, 183, 185
CT violation, 193, 198
Curie’s principle, 16, 18, 19, 181–3, 190
- decoherence, 133, 134
definability problem, time reversal, 22–4, 48
Democritus, 10, 56, 65
Dirac, Paul, 15, 16, 55, 201, 215
direct empirical significance, 85, 98–101, 114
dynamical symmetry, 85–95, 105–14
 classification into two types, 92, 93
dynamical system, 4–6, 10, 11, 20, 29, 31, 36, 38, 42, 46, 47, 50, 51, 53, 54, 65
- Earman’s Conjecture, 122
Eddington, Arthur, 115
Ehrenfest–Afanassjewa, Tatiana, 149, 153, 155, 157, 159, 160
electroweak theory, viii, 2, 19, 111, 113, 131, 137, 169–72, 175–80, 184, 185, 187–91, 193, 195, 197, 198, 206
energetic degeneracy, 15
energy, half-bounded, 54–6

- engines, 7–10
entropy, 10–13, 116, 122–5, 127, 128, 136, 137,
140–4, 148–50, 154–64, 166
representation, 151, 163–6
equations of state, 152
Euler–Lagrange equations, 72, 73, 90, 109
Everett interpretation, 35, 134–6
extensive thermodynamic variables, 152
- Feynman, Richard, ix, 17, 122, 133, 147, 192–4,
198–200, 212, 217
Feynman diagrams, 198, 199
Feynman view of antimatter, 192–4, 198–205,
212, 217
- film analogy, time reversal, 10, 23, 144
first law of thermodynamics, 147, 148, 150, 151,
166
Fitch, Val, 18, 19, 179, 180, 183, 185
Fock, Vladimir, 21
Fock space, 55, 202
fork asymmetry, 137
Frege, Gottlob, 85, 99, 101–3
morning star, evening star, 102, 103
friction, 174
functionalism, 22, 33–5, 39, 40, 59, 118, 172
fundamental relation, Gibbs, 151, 163
- Galilei group, 43, 64, 70, 71, 79, 81, 94, 110, 111,
197
Galileo's ship, 98–100
Gibbs one-form, 150, 151
group element, time reversal, 43–6
Gruppenpest, 84
- Hamilton's equations, 66–70, 72, 73, 90, 109
harmonic oscillator, 30, 55, 59, 62, 103, 174–6
damped, 174–6
Hawking, Stephen, 128, 129, 136, 140
Hawking–Hartle no-boundary, 128, 129
heat, 7–10, 145, 147
one-form, 147–50
higher-order symmetry, 99–101, 204
- instantaneous time reversal, 24–8, 37, 46–50, 52,
53, 73–5, 78, 79
integral submanifold, 151
intensive thermodynamic variables, 152
inverse processes, 8, 9
involutions, 39, 40, 43, 213
irreversibility, thermodynamic, 139, 143, 149,
156–9, 161
Ising lattice, 111–13
- Jauch, Josef M, 54, 78, 149, 155, 157, 160
jet space, 52, 59, 62
- Kabir's principle, 183, 184, 190
kaon, 17, 18, 23, 116, 174, 180–5, 188, 190
- Kelvin's principle, 160–2
kinematical symmetry, 87
Klein four-group, 84, 85, 102, 105
- Lagrangian mechanics, 72, 73
law of motion, 4, 6, 11, 15, 16, 19, 53, 58, 59, 102,
122, 124, 130, 131, 136, 137, 139, 169, 170, 188,
190, 219
Legendre submanifold, 151
Leibniz, Gottfried, 33, 58, 84, 86, 101, 102
Leibniz Equivalence, 102
Lie algebra, 54
Lie group, 34
Lorentz group, 43, 70, 79, 81, 179, 194, 197, 205,
206, 209–11, 213, 214
Lorentzian manifold, 41, 69, 107
Loschmidt, Josef, 12
- Möbius strip, 81, 207, 208
Malament time reversal, 42, 43, 70, 168
matter–antimatter exchange, 17, 18, 129, 178, 193,
194, 198, 199, 202–6, 208, 209, 211–18
McTaggart, 2–4, 6, 20, 115
Minus First Law, 143–5, 162, 166
mire, metaphysical, 3
mixed state, 15, 95–7
mixture, thermodynamic, 142–4, 154, 160, 161
motion reversal, 15, 22, 26, 27, 50, 56, 63
- Navier–Stokes theory, 65
Newton's second law, 59, 60
nomic asymmetry, 169
- operationalism, 22, 23, 25, 74, 100, 101, 112, 113
for time reversal, 25, 99, 100
- P violation, 16, 17, 169, 180, 185, 195, 198, 206,
211, 217
Painlevé, Paul, 13, 14
Pais, Abraham, 18
pancake view of time reversal, 24
passage of time, 2, 3, 28, 31, 38, 39, 52, 99, 107,
152, 153, 159, 219
Past Hypothesis, 13, 123
Pauli spin observables, 80–2, 111, 112, 207, 210,
216
pion, 16, 18, 19, 181–3, 190
Poincaré group, 43, 45, 46, 89, 93, 94, 101, 109, 111,
189, 198, 205, 206, 211–14
Poincaré lemma, 67, 156
Price's table, 117–19, 168, 169, 171, 173, 186, 187,
191, 219
principle of detailed balance, 183
Principle of Relativity, 98
Principle of the Common Cause, 136, 137
problem of falling cats, 13–15
promissory note, author's reckless, 217

- PT operator, 64, 65, 113, 185, 195–8, 200, 206, 211, 218
 PT violation, 206, 211
 pure state, 15, 95
- quantisation, 26, 71, 194, 198–205, 218
 quantum theory, 73–82, 88, 91, 94–7, 99, 108, 111–13, 130–6, 176–85
 time reversal, 77–80, 94–7
 time reversal of spin, 80–2
 quasistatic process, thermodynamic, 153, 154
- radiation arrow, 119–22
 reduction, intertheoretic, 33
 reduction, quantum state, 116, 131–3
 reduction, thermodynamics to statistical mechanics, 140
 reference, semantic, 86, 93, 94, 102–5
 Reichenbach, Hans, 33, 122, 136, 137, 140, 141, 168
 relationism, 32, 33, 168
 renormalization, 171, 174, 176–8, 184, 191
 Representation View, 4–6, 21, 22, 29–32, 36, 43, 46–8, 50, 54, 73, 80, 81, 84–6, 88, 90–3, 95, 97–9, 106–8, 114–16, 118, 153, 170–2, 177–9, 186–8, 191, 196
 reversibility paradox, 12, 13
 Ritz–Einstein debate, 119–22
- S-matrix, 181–4
 Schur’s lemma, 71, 79, 82, 198, 211
 second law of thermodynamics, 10, 141–3, 145, 152, 155–7, 160–3, 166
 Gibbs formulation, 162–6
 Planck formulation, 159–62
 semidirect product, 43–6, 56, 61, 76, 204, 206, 211, 212
 Series, A, B, and C, 2–4, 6, 20
 sophistication, spacetime symmetry, 104
 SP1, Earman’s symmetry principle, 86, 106, 107
 SP2, Earman’s symmetry principle, 86, 106–14, 170
 Spacetime–Evidential link, 117, 119, 137, 169, 170, 173
 spinors, 106, 200, 214–17
 spontaneous symmetry breaking, 110–13, 173
 Standard Model, 19, 174–80, 184, 185, 193, 198, 200, 212
 state space, 4, 22, 24, 27–32, 41, 43, 46–66, 68, 72, 73, 75, 78, 81–3
 Hamiltonian state space, 66, 67, 88
 Lagrangian state space, 72, 73
 Newtonian state space, 59–61
 quantum state space, 75, 76, 79, 80, 82, 88
 stationary state, 11, 12
 statistical mechanical arrow, 10–13, 122–6
 Stone’s theorem, 76, 78
 Stoßzahlansatz, Boltzmann, 123–5
 structural realism, 33, 172
 structure, temporal, 32–9, 41
 substantivalism, 32, 33, 171
 superselection, 15, 95–7
 supervenience, 37, 63, 106
 Symmetry Existence Criterion, 47, 54, 93–7, 173
 symmetry-to-reality inference, 102–5, 114
 symplectic mechanics, 66–71, 88, 107, 110, 111, 173
 formulation of electromagnetism, 69, 70
- T violation, 4, 18–20, 47, 79, 93, 95–7, 110, 111, 113, 114, 116, 129, 131, 132, 154, 157, 161, 169–71, 173–91, 194–8, 205, 206, 211, 212, 217, 218
 direct, 19, 181, 183, 184
 temperature, 148–50
 temporal orientation, 3, 41, 42, 70, 116, 127, 168–72, 188, 189
 temporal sequence, 24
 temporal symmetry, 89–95, 107–14
 The Representation View, 29
 thermodynamic mixing, 142–4, 154, 160, 161
 thermodynamic phase space, 151
 thermodynamic system, equilibrium, 151, 153, 154, 163
 theta-tau puzzle, 16, 17
 time observables, 99, 100
 time order reversal, 24–8, 37, 39, 41, 46–9, 73–5, 78, 79
 time translations, 21, 31, 34–9, 41–3, 53, 54, 171–4
 Newtonian, 58–61
 quantum theory, 76–80
 symplectic mechanics, 66, 67
- Uhlhorn’s theorem, 76, 77
 universal covering group, 206–11, 218
 use–mention distinction, 103
- Weinberg, Stephen, 17, 18, 178
 Wheeler, John, 122, 192, 193
 Wigner, Eugene, 4–6, 14, 15, 26, 27, 29, 74–8, 84, 95–7, 179, 208, 217
 Wigner time reversal, 14, 26, 27, 74–80, 95–7
 Wigner’s theorem, 76
 Wittgenstein, 6
 work, 8–10, 147–50, 160, 161, 165, 166
 Wu, Chien-Shiung, 17, 180, 185, 198, 217

