

Index

A

Adjoint (representation), 111
Antilinear (operators), 527
Antiunitary (operators), 527
Axial (vector), 236

B

Bargmann (theorem), 145
Bose–Einstein (condensation), 515
Bracket (Poisson), 21
Breaking (of symmetry), 507

C

Casimir operator, 114
Cayley (theorem), 52
Character(s), 61
Clebsch–Gordan (coefficients), 334
Coefficients 3-j, 347
Coefficients 6-j, 351
Color charge (quarks), 495
Compact (group), 85
Condensation (Bose–Einstein), 515
Conjugacy classes, 53
Conservation laws, 293
Constants
 extension, 136
 structure, 137
Continuous (groups), 70
Coset of a subgroup, 65
Coupling (minimal), 257, 263
Crystallization, 515
Current (conservation), 40

D

Decomposition (Gordon), 280
Diagram (root), 479
Dipole
 electric, 423
 magnetic, 432, 435

optical transitions, 390

Dirac (equation), 258, 273, 300
Distinguishable (particles), 452
Double-valued representation, 316, 346

E

Energy (internal), 166
Equation(s)
 Dirac, 258, 273, 300
 Hamilton, 19
 Klein–Gordon, 254, 297
 Lagrange, 9
 Poisson, 416
 Schrödinger, 247, 251, 295
 Weyl, 264
Equivalent (particules), 451
Euler
 angles, 216
 and Lagrange points of view, 31
Extension
 constants, 136
 Lie algebra, 134

F

Factors (phase), 133
Faithful representation, 58
Ferromagnetic, 512
Ferromagnetism, 511
Flavor (quarks), 492
Form (Killing), 111
Four-vector (operators), 176, 284, 286

G

Galilean and Poincaré groups, 98
Galilean transformation, 23, 86, 159,
 242
Generators (infinitesimal), 79, 131
Gordon decomposition, 280
Group(s)
 Abelian, 46

commutative, 46
compact, 85
continuous, 70, 130
cyclic, 47
Galilean, 98
 $GL(2, C)$, 77
homotopy, 76
isomorphic, 50
Lie, 76
Lorentz, 191
permutations, 48
Poincaré, 103, 173, 254
representations, 56, 117
simple, 53
simply connected, 142
 $SL(2, C)$, 191
 $SO(3)$, 95, 98, 317
 $SU(2)$, 89, 339, 449, 520
 $SU(3)$, 449
tensor product, 55
theory, 45
 $U(1)$, 520

H

Hamilton's equations, 19
Helicity, 185, 286
Higgs (mechanism), 520
Homomorphism between $SU(2)$ and rotations, 339
Homotopic paths, 73, 96
Homotopy, 73
Homotopy (group), 76

I

Identical (particles), 456
Infinitesimal generators, 79, 131
Interference between two condensates, 516
Invariant subgroup, 53
Irreducible (representations), 62
Isospin, 466

J

Jacobi identity, 21

K

Killing form, 111
Klein–Gordon (equation), 254, 297
Kramers
 conjugates, 550
 theorem, 548

L

Lagrange's equations, 9
Lagrangian density, 38, 294
Lagrangians for wave equations, 293
Lee and Yang, 238
Lemma (Schur), 381
Lie algebra, 82
 extension, 134, 159
 structure constants, 82
Lie groups, 76
Limit (non-relativistic limit of the Dirac equation), 276
Lorentz (group), 191
Lorentz little group, 198
Lorentz transformations, 103, 173, 283

M

Magnetic multipole moments, 428
Magnetism, 508
Mass, 166, 176
Matrices (Pauli), 89
Microreversibility, 546
Minimal coupling, 257, 263
Moments (magnetic multipole), 428
Moments (multipolar), 415
Multipole moments, 415
 electric, 416

N

Newton's equations, 6
Noether theorem, 13, 38

O

- O(2), 77
- Observables
 - transformation of, 126
- Operator(s)
 - antilinear, 527
 - antiunitary, 527
 - Casimir, 114
 - four-vector, 176, 284, 286
 - irreducible tensor, 368
 - mass, 176
 - position, 102, 170, 183, 244
 - scalar, 165, 358
 - spin, 168, 179, 286
 - tensor, 363
 - vector, 358
 - velocity, 244, 263, 289
- Optical (dipole transitions), 390
- Orbital (angular momentum), 167
- Order (of a tensor), 364

P

- Parity, 233
- Parity violation, 238
- Particles
 - distinguishable, 452
 - equivalent, 451
 - identical, 456
- Paths (homotopic), 73, 96
- Pauli matrices, 89
- Pauli–Lubanski vector, 180, 207
- Permutation, 497, 503
- Phase
 - factors, 133
 - spontaneous emergence of, 515
- Poincaré group, 103, 173, 254
- Poisson bracket, 21
- Poisson equation, 416
- Polar (vector), 236
- Position (operator), 102, 170, 183, 244
- Precession (Thomas), 106, 173, 197

Product

- of two representations, 61
- tensor (direct) product, 55

- Projective representation(s), 58, 133, 141

Q

- Quadrupole(electric), 425, 435
- Quarks, 492
- Quotient group, 66

R**Rank**

- of a Lie algebra, 479
- of a tensor, 364

- Rapidity, 107, 194, 197, 283

- Rearrangement lemma, 47

- Reducible (representations), 62

Relativistic invariance

- Dirac equation, 273, 301
- Klein–Gordon equation, 298
- Weyl equation, 265

Representation(s)

- adjoint, 111
- double-valued, 316, 346
- equivalent of a group , 60
- faithful of a group, 58
- finite, 138
- in the state space, 158, 241
- linear of a group, 56, 128
- projective, 133, 141
- projective of a group, 58
- reducible and irreducible, 62
- sum and product, 61
- symmetric and alternating square, 64

Root diagram, 479**Rotations**

- group, 94, 216, 281, 303
- matrices, 218, 312, 314
- representations, 303
- symmetry of observables, 355

S

Scalar (operators), 165, 358
Schrödinger (equation), 247, 251, 295
Schur (lemma), 381
Second-order (tensors), 368, 409
Simple (group), 53
Simply connected (group), 142
SL(2, C), 191
SO(2), 77, 85
SO(3), 95, 98, 314
Space reflection, 233
Spin, 168
Spin (operator), 179, 286
Structure constants, 82, 133
 completely antisymmetric, 113
SU(2), 89, 339, 449, 520
SU(3), 449
Subgroup, 52
 invariant, 53
Sum of two representations, 61
Symmetries
 classical mechanics, 5
 quantum mechanics, 26
Symmetrization of a state vector, 497,
 503
Symmetry
 breaking, 507
 change of, 503
 Galilean and Poincaré, 98
 rotation, 95, 98, 355
 transformations, 1

T

Tensor operators, 363
 irreducible, 368
Tensors
 irreducible, 405
 review, 397
 second-order, 409
 second-order irreducible, 368
 symmetric and antisymmetric, 403

Theorem

Bargmann, 145

Cayley, 52

Kramers, 548

Noether, 13, 38

Uhlhorn-Wigner, 149

Van Vleck, 552

Wigner, 121

Wigner–Eckart, 379

Thomas precession, 106, 173, 197

Time reversal, 521

Topology (intuitive notions), 71

Transformations

 Galilean, 23, 86, 99, 159, 242

 Lorentz, 103, 173, 193, 283

 of observables, 126

Transitions (optical dipole), 390

U

Uhlhorn theorem, 149

Unimodular matrix, 192

Universal covering group, 98

V

Van Vleck theorem, 552

Vector

 operators, 358

 Pauli–Lubanski, 207

Velocity operator, 244, 263, 289

W

Weyl equation, 264

Wigner’s theorem, 121

Wigner–Eckart theorem, 379

Wu (experiment of Mrs), 238