

## Index

### Symbols

4-vector of current density, 320, 339

### A

action for an electromagnetic field, 320

adiabatic invariants, 306

amplitude, complex, 143

angular momentum tensor of an

electromagnetic field, 389

annihilation  $e^+ + e^-$ , 672

annihilation and creation operators, 517

anomalous magnetic moment, 668

antiparticles, 563

asymptotic value

– of cylindrical functions, 45

– of modified Bessel functions, 46

– of spherical Bessel functions, 47

### B

basis, mutual, 11

Bessel function

– integral representation, 43

– recurrent relations, 43

big canonical distribution of Gibbs, 695

bispinors of a free particle, 572

Bohr magneton, 174

boundary conditions

– for Maxwell's equations, 134

– in magnetostatics, 118

– periodic, 150

Breit formula, 367

bremsstrahlung, 425

### C

Casimir effect, 520

causality principle, 398

charge

– electric, 281

– elementary, 92

– magnetic, 312

Christoffel symbols

– of the first kind, 33

– of the second kind, 32

chronological operator, 651

classical electron radius, 270

coefficient

– of mutual induction, 126

– of self-induction, 127

combinational (Raman) scattering, 612

completeness of a system of functions, 65

Compton effect, 229, 573

Compton wavelength, 270

condition of completeness (closeness), 66

conduction current, 133

continuity equation, 115

coordinate system, affine, 11

critical (Eddington) luminosity, 447

### D

d'Alembert's wave equation, 142

degree of depolarization, 146

degree of polarization, 146

density

– of electric current, 113

– of electromagnetic energy flux, 137

– of the energy of electromagnetic field,

137

derivative

– covariant, 31

– from delta function, 58

differential operations

– in cylindrical coordinates, 37

– in spherical coordinates, 37

dipole moment

– electric, 101

– magnetic, 120

dipole moment of the transition, 545

Dirac equation, 561

Dirac matrices, 561

- Dirac  $\gamma$  matrices, 631
  - Dirac's monopoles, 312
  - Dirac–Lorentz equation, 440
  - direction of rotation of electrical vector, 185
  - dispersion relations, 149
  - displacement current, 133
  - distribution
    - Gibbs canonical, 694
    - Planck, 521
    - Poisson, 524
  - divergence, covariant, 35
  - Doppler effect, 210
    - in a refractive medium, 231
  - Doppler width of the spectral line, 496
  - double electric layer, 101
  - drift
    - centrifugal, 308
    - electric, 302
    - gradient, 303
  - dual tensors, 276
- E**
- Earnshaw
    - theorem, 111
  - Einstein coefficients, 544
  - electric charge, 91
  - electric dipole transition, 545
  - electric field, 93
  - electric polarization vector, 408
  - electric quadrupole moment, 101
  - electromagnetic potentials, 138
  - electromotive force of induction, 132
  - electrostatic Gauss theorem, 95
  - electrostatic potential, 94
  - elliptic point, 305
  - emission
    - of pulsar, 413
    - spontaneous and stimulated, 543
  - energy
    - kinetic, 217
    - relativistic total, 216, 217
  - energy efficiency of a reaction, 220
  - energy–momentum tensor of electromagnetic field, 328
  - equation
    - Bessel, 44
    - Helmholtz, 31
    - inhomogeneous d'Alembert, 139
    - of Legendre, 52
  - equation for the density matrix, 694
  - equivalent photons, 577
  - Euclidean geometry of three-dimensional space, 194
  - Euclidean space, 1
  - evolution operator, 648
  - expansion in multipoles, 101, 102
- F**
- Feynman diagrams, 574, 655, 663, 666, 671, 672
  - Feynman's electron propagator, 659
  - Feynman's photon propagator, 662
  - field spin, 388
  - field vacuum fluctuations, 517
  - fine structure constant, 540
  - Fizeau experiment, 213
  - formula, Klein–Nishina–Tamm, 577
  - formulas, Sokhotskii, 62
  - four-dimensional
    - force, 285, 286
    - photon polarization, 646
    - pseudotensors, 275
    - space–time, 196
    - vector, 205
  - Fourier image of a function, 69
  - frequency, circular, 143
  - F-sum rule, 558
  - full set of observables, 688
  - function
    - Bessel, 41
    - Bessel modified, 46
    - generating Bessel functions, 41
    - Legendre, spherical, 54
    - Neuman's, Weber's, Hankel's, 45
    - step, Heaviside, 58
  - function generating Legendre polynomials, 49
- G**
- Galilean transformations, 195
  - gauge transformation of potentials, 138, 290
  - Gauss–Ostrogradskii theorem
    - generalized, 80
  - general properties of wave functions, 687
  - generalized currents Noether, 325
  - Green's function
    - advanced, 401
    - retarded, 397
  - Green's identities, 30
  - gyromagnetic ratio, 298
- H**
- Hamiltonian function, 287
    - of field oscillators, 153
  - Hamilton–Jacobi equation, 287
  - hard Vavilov–Cherenkov radiation, 232
  - Heisenberg's uncertainty relations, 690
  - Higgs boson, 385

Hilbert transforms, 149  
 homogeneity of time, 194  
 hyperbolic point (saddle), 306  
 hyperfine splitting, 549

**I**

identity, Parseval's, 65  
 inequality, Bessel's, 65  
 inertial frames of reference, 194  
 integral form
 

- of electrostatics equations, 95
- of magnetostatics equations, 117

 integral form of the law of electromagnetic induction, 133  
 integrals of motion, 692  
 intensity of radiation, 400  
 interaction representation, 551, 648  
 internal bremsstrahlung, 427  
 interval
 

- and causality, 203
- light like (zero), 203
- space like, 203
- time like, 203

 invariant kinematic variables, 221  
 inversion of coordinate systems, 3

**K**

Klein–Gordon–Fock equation, 381, 563

**L**

Lagrange function density, 680  
 Lagrangian form of equations of motion, 682  
 Lagrangian function
 

- of a nonrelativistic particle, 215
- of a relativistic particle, 216
- of a relativistic particle in an electromagnetic field, 283

 Lamb shift, 520, 585  
 Lamé coefficients, 35  
 Landau levels, 624  
 Larmor
 

- formula, 406
- radius (gyroradius), 347
- theorem, 309

 law
 

- of the conservation of electric charge, 92, 115
- Rayleigh–Jeans, 588
- Wien, 589
- Wien displacement, 588

 Legendre polynomials, Rodrigues formula, 51  
 Lienard–Wiechert potentials, 417  
 long-range interaction, 282

Lorentz contour, 191  
 Lorentz contraction of the length, 201  
 Lorentz force, 280  
 Lorentz transformation of a bispinor, 632  
 Lorentz transformations, 198

**M**

macroscopically small volume, 92  
 magnetic flux, 124  
 magnetic moment
 

- orbital, 298
- spin, 299

 magnetic polarization vector, 409  
 mass defect, 220  
 matrices, Pauli, 566  
 matrix
 

- of Lorentz transformation for a bispinor, 632
- of rotation, 2

 Maxwell tension tensor, 328  
 Maxwell's equations in 4-form, 322  
 metric tensor, 13, 15  
 momentum, relativistic, 216  
 Mott formula, 657

**O**

occupation numbers, 517  
 operations of differentiation in orthogonal coordinates, 36  
 operator
 

- Hamilton's (nabla), 19
- Laplace, 28
- of a derivative on time, 692
- of density, 693
- self-conjugate (Hermitian), 690

 operators of the Dirac field, 642  
 orbital moment of the field, 387  
 orthogonality of Bessel functions, 48  
 orthonormalized system of functions, 64  
 oscillator strength, 558  
 oscillators of the field (principal coordinates), 151

**P**

particle, ultrarelativistic, 219  
 Paschen and Buck effect, 570  
 Pauli equation, 566  
 phase of plane monochromatic wave, 143  
 phase portrait, 305, 306  
 phase trajectory, 305, 306  
 photon, 219  
 Planck constant, 219  
 Planck spectral distribution, 588  
 plane wave, 142, 184

- Poisson equation, 95
  - polarizability
    - electrostatic, 558
  - polarization of a plane monochromatic wave, 144
  - polarization vector of relativistic electron, 638
  - polynomials, Legendre, 49
    - adjoint, 52
  - potential
    - function, 125
    - pseudoscalar of a magnetic field, 123
    - vector, 116
  - Poynting vector, 137
  - principle
    - of correspondence, 688
    - of relativity of classical mechanics, 194
    - of reversibility, 409
    - of the constancy of the speed of light, 196
    - of the superposition of states, 689
  - principle of the superposition of fields, 93
  - probability current, 565
  - probability density, 564, 686
  - projection operator, 634, 691
  - projection operators onto the positive and negative energy state, 635
  - proper time, 200
  - pure states, 685
- Q**
- quantum number, 685
- R**
- radiation friction force, 440
  - radiation width of spectral line, 556
  - Rayleigh scattering, 559
  - Rayleigh–Jeans law, 588
  - reference frame, center of inertia, 220
  - relativistic factor (Lorentz factor), 219
  - relativistic motion in a Coulomb field, 362
  - renormalization of mass, 440
  - rest energy, 216
  - rule of relativistic velocities composition, 202
  - runaway electrons, 360
  - Rutherford formula, 356
- S**
- scalar
    - definition, 2
    - potential, 138
  - scattering matrix, 535, 649
  - Schrödinger and Heisenberg representations, 692
  - Schrödinger equation, 683, 692
  - selection rules, 548
  - separatrix, 306
  - singular point, 306
  - singular points of phase plane, 306
  - spectral line broadening
    - collisional, 496
    - Doppler, 496
    - natural, 495
  - spectral line broadening, natural, 556
  - spectrum of a physical value, 685
  - spherical functions of Bessel and Hankel, 46
  - spherical vectors, 403
  - spin of elementary particles, 174
  - spin–orbital interaction, 570
  - spirality, 640
  - Stark effect, 570
  - state
    - entangled, 538
    - quasi-stationary, 556
    - stationary, 693
  - states
    - coherent, 523
    - mixed, 693
    - squeezed, 529
  - statistical sum, 694
  - Stokes theorem, 26
  - strength
    - of an electric field, 93
    - of magnetic field, 112
  - superfine splitting, 569, 619
  - superradiance, 618
  - superradiance effect, 618
  - surface density of the charge, 96
  - surfaces, equipotential, 21
  - symmetry and antisymmetry of wave functions, 688
  - synchrotron radiation, 431, 432
  - system of coordinates
    - bispherical, 39
    - ellipsoidal, 38
    - extended spheroidal, 39
    - flattened spheroidal, 38
    - toroidal, 40
- T**
- tensor, 17
    - axial (pseudovector), 3
    - definition, 2
    - energy–momentum, canonical, 326
    - Hermitian (anti-Hermitian), 4
    - metric, 13, 15
    - of electromagnetic field, 284
    - of polarization, 144
    - polar, 3

- symmetric
    - principal directions, 9
    - principal values, 9
  - symmetric (antisymmetric), 4
  - theorem
    - Gauss–Ostrogradskii, 25
    - of the uniqueness of the solution of Maxwell's equations, 137
    - Stokes, 26
    - Stokes' generalized, 31
    - the summation of spherical functions, 54
  - Thomas precession, 208, 367, 372
  - Thomson cross-section, 498, 501, 559
  - total field moment, 388
  - transform, Fourier, 69
  - transitional current, 542
  - transversality of electromagnetic waves, 142
- U**
- undulator, 432
  - undulator radiation, 432
  - uniformity and isotropy of space, 194
  - unitary operator, 691
- V**
- vacuum fluctuations, 517
  - Vavilov–Cherenkov effect, 231
  - vector
    - axial (pseudovector), 3
    - basic, 16
    - definition, 2
    - polar, 3
    - spherical, 403
    - wave, 143
  - vector circulation, 22
  - vector potential, 27
  - vector solenoidal, 27
  - virial theorem, 354
  - volume density of a charge, 92
- W**
- wave zone, 400
  - Wien's displacement law, 588
  - world line, 202