

Index

a

Abbe number 9
 Abbe sine condition 175
 Abbe's refractometer 25
 ABCD matrices 18
 conventions 18
 Gaussian modes 44
 wave guides 23
 aberrations 169
 chromatic 176
 spherical 173
 Abraham–Lorentz equation
 220, 222
 absorption 380
 cross section 237
 in optical materials 95
 saturated 381
 achromats 177
 acousto-optical modulator (AOM)
 114, 306
 AC Stark shift 410
 AC Stark splitting 408
 adiabatic elimination 292
 Adler equation 343
 afocal system 22, 166
 air laser 264
 Airy disc 70
 Airy function 199
 alpha parameter 288
 amplifier noise 358
 amplitude noise 298
 angle matching 471
 anharmonic oscillator 457
 anisotropic optical materials 103
 anomalous dispersion 221

AOM (acousto-optical modulator)
 114, 306

aperture aberration 173
 argon laser 261
 astigmatism 174
 atomic beams 388
 atom optics 25, 187
 Autler-Townes doublet 408
 Autler-Townes splitting 410
 autocorrelation function 430
 avalanche photodiodes 374

b

Babinet's principle 74
 bandgap, photonic 136
 beam splitter 184
 Bell experiment 453
 Bell's inequality 450
 Bennett holes 256
 birefringence 103
 beam walk-off 106
 microscopic model 104
 polarizers 109
 strain 104
 uniaxial crystals 104
 birefringent filter 108, 282
 Bloch–Siegert shift 233
 Bloch's theorem 135
 Bloch waves 134
 bolometer 366
 Bragg diffraction 115
 pendulum solution 116
 Brewster angle 87
 Brewster condition 87

c

candela 377
 cat's-eye 8
 cavity dumping 306
 cavity QED 426
 cavity ring down spectroscopy 217
 celeritas 34
 channeltron 370
 chaotic field 435
 chaotic light field 441
 charge-coupled device (CCD)
 sensors 375
 chemical vapor deposition
 (CVD) 12
 chirped pulse amplification 313
 chromatic aberration 176
 cladding pumping 276
 Clauser–Horne–Shimony–Holt (CHSH)
 inequality 452
 Clausius–Mossotti equation 228
 coherence 181, 182
 first-order 435
 function 430
 longitudinal 191
 second-order 435, 436
 temporal 192
 transverse 186
 coherent control 407
 coherent states 439
 coherent superposition 414
 CO₂ laser 265
 colour centre laser 280
 coma 175
 concave mirror 16
 astigmatic aberration 16
 astigmatism 16
 confocal parameter 42
 conjugated plate 27
 continuity equation 33
 contracted notation 462
 corner cube reflector 8
 corner frequency 358
 Cornu spiral 73
 correlation function 183, 428
 cosmic background radiation 240
 Coulomb gauge 32
 coupled amplitude equations 465

crystal field splitting 270
 current noise 499
 curved mirrors 15
 CVD (chemical vapor deposition) 12

d

dark current noise 357
 dark field imaging 160
 dark state 455
 defect mode 139
 density-matrix formalism 504
 density of states 505
 dephasing 413
 depolarizing field 228
 depopulation pumping 391
 depth of focus 161
 detectors
 photovoltaic 372
 pyro-electric 366
 quantum 353
 thermal 353
 dielectric function 225
 dielectric interfaces 83
 dielectric media 30
 optically dense 227
 optically thin 225, 226
 dielectric susceptibility 30, 225
 difference frequency 478
 diffraction 63, 84
 Bragg domain 115
 grating 188
 Raman–Nath domain 115
 digital light processing (DLP) 114
 digital mirror device (DMD) 113
 diode laser
 amplitude modulation 340
 arrays 349
 dynamics 339
 extended cavity 346
 external cavity 346
 heterostructure 330
 high-power 348
 linewidth 341
 optical feedback 344
 phase modulation 341
 quantum well 336
 tapered amplifier 349

tunable 345
 wavelength 332
 wide stripe 349
 dioptre 20
 dipole character 39
 dipole interaction 230
 dipole operator 230, 422
 dispersion 9, 380
 length 100
 relation 127
 distortion (aberration) 175
 distributed Bragg reflector
 (DBR) laser 346
 distributed feedback (DFB)
 laser 346
 Doppler effect
 broadening 255
 second order 393
 Doppler width 385
 double slit
 atomic beams 187
 electron beam 187
 Drude model 89
 dye laser 281

e

Einstein coefficients 241, 242
 Einstein–Podolsky–Rosen (EPR)
 paradox 448
 electric polarizability 222
 electromagnetic field
 energy density 35
 momentum current density 37
 quantization 418
 electro-optical modulators (EOMs)
 110
 half-wave voltage 111
 erbium-doped fiber amplifiers (EDFAs)
 275
 erbium laser 275
 etalon 197
 intra-cavity 256
 evanescent wave field 88
 excimer laser 267
 eye 149, 151
 adaption 151
 eyepiece 153

f

Fabry–Perot interferometer 197
 resolution 202
 Fabry–Perot spectrum
 analyser 259
 Faraday effect 117
 Faraday isolator 118
 Faraday rotators 117
 femto-chemistry 113
 Fermat’s principle 5
 fiber absorption 130
 fiber Bragg gratings (FBGs)
 277
 fibre laser 276
 field operator 419
 filter, spatial 131
 finesse 201
 coefficient 199
 flicker noise 358
 fluorescence microscopy 161
 focal point 15
 Fock state 439
 focus 15
 Fourier components 32
 Fourier optics 70, 159
 four-level system 243
 four-wave mixing (FWM) 485
 Fraunhofer diffraction 67
 circular aperture 69
 Gaussian transmitter 69
 single slit 68
 free induction decay (FID) 411
 free spectral range 200
 frequency chirp 100, 495
 frequency combs 315
 frequency doubling 466
 Gaussian beams 472
 resonant 474
 strong conversion 468
 weak conversion 467
 frequency modulation 111
 frequency tripling 485
 Fresnel diffraction 67, 71
 circular aperture 73
 straight edge 72
 Fresnel formulae 86
 Fresnel lenses 75

- Fresnel zones 75
- frustrated total internal reflection (FTIR) 88
- full width at half-maximum (FWHM) 382
- g**
- gain
 - saturated 250, 256
 - small signal 256
- GaN laser 323
- gas lasers 261
- Gaussian beams 40
 - ABCD rules 44
 - beam radius 43
 - beam waist 42
 - confocal parameter 42
 - divergence 43
 - Gouy phase 43
 - higher modes 47
- Gaussian principal mode 41
- Gaussian rays 41
- Gauss–Voigt profile 384
- Glan polarizers 109
- Glauber state 439
- graded-index (GRIN) fiber 129
- grating
 - blazed 189
 - holographic 189
 - laser 345
 - resolution 190
- gravity wave interferometer 194
- GRIN lens 14, 23
- group index of refraction 98
- group velocity 98–99
- h**
- Hagen–Rubens relation 91
- half-width at half maximum (HWHM) 382
- halo 26
- Hanbury-Brown and Twiss experiment 437
- Hanle effect 224
- HE/EH modes 128
- Helmholtz equation 35
 - paraxial 47
- Hermitian–Gaussian modes 47
- Hermitian polynomials 48
- Hertzian dipole 39
- heterodyne detection 364
- heterostructures 329
- hidden variables 450
- hole burning 282, 388
- holes, spectral 256
- hologram
 - in-line 211
 - reconstruction 212
- holography 210
 - recording 211
- homodyne detection 364
- homostructures 329
- Hong–Ou–Mandel dip 448
- Hong–Ou–Mandel interferometer 446
- host crystals 268
- hot spot 75
- Hubble Space Telescope 168
- Huygens eyepiece 153
- Huygens’ principle 63
- hybrid modes 126
- hydrogen atom, spectroscopy 392
- i**
- image amplifiers 377
- image converter 377
- image sensors 374
- image, stigmatic 15
- indexellipsoid 105
- index of refraction 3
 - extraordinary 104
 - inhomogeneous 6
 - intensity-dependent 101
 - negative 144
 - ordinary 104
- indicatrix 105
- injection locking 342
- interband, intersubband transitions 338
- interferometry 181
 - Hong–Ou–Mandel 446
- intrinsic permutation symmetry 461
- inversion 231, 235, 236, 243

j

Jaynes–Cummings model 297, 422
 Jones formalism, matrices 54
 Jones vectors 52

k

Kerr effect 110
 Kerr lens mode locking (KLM) 310, 489
 Kirchhoff's integral theorem 65
 Kleinman symmetry 462
 KNbO₃ 472
 Köhler illumination 156
 Kramers–Kronig relations 247

l

Laguerre–Gaussian modes 78
 lambda half/quarter plates 107
 lambda meter 193
 Lamb dip 256
 Lamb shift 418
 lanthanides 269
 Larmor formula 221, 242
 Larmor frequency 223
 laser 249

- amplitude noise 302
- cooling 394, 398
- disc 278
- end-pumped 273
- fluctuations 302
- gain profile 255
- granulation 214
- gyro 197
- helium–neon 251
- high-power 312
- line selection 254
- linewidth 258
- mode selection 254
- neodymium 271
- noise 298
- outcoupling 258, 291
- power 257
- pulsed 305
- rate equations 291
- RIN 303
- single-atom 296
- single-frequency 256

- single-mode 256
- speckle 214
- spectroscopy 379
- spiking 292
- theory 285
- threshold-less 295
- transition-metal ions 279
- types 251
- white light 313

laser diode, inversion 325
 laser-induced fluorescence (LIF) 379
 laser resonator

- bowtie 282
- Z-shaped 273

 laser threshold 290
 law of refraction 3
 least distance of distinct vision 151
 lenses 15

- aberrations 169
- achromatic 177
- afocal systems 22
- biconvex 171
- designs 170
- diffraction limit 46
- GRIN 23
- magnetic 24
- matrix 20
- meniscus 171
- periodic systems 22
- planar convex 170
- systems 21
- thick 20
- thin 20
- types 170

 LIF (laser-induced fluorescence) 379
 light field, nonclassical 437
 light forces 394
 light propagation in matter 83, 121
 light pulses 94

- distortion 100
- spectrum 95

 light rays

- extraordinary 106
- ordinary 106

 light sensors 353
 light shift 410
 line shapes 382

- linewidth 382
 - Doppler 383
 - heterodyne method 259
 - homogeneous 383
 - inhomogeneous 385
 - natural 383
 - phasor model 300
 - pressure broadening 385
 - time-of-flight 386
 - liquid crystal (LC) modulator 113
 - lock-in amplifier 404
 - longitudinal relaxation 236
 - Lorentz field 228
 - Lorentz oscillator, in magnetic field 223
 - Lorentz profile 221
 - LP modes 128
 - lumen 377
 - Lyot filter 108, 282
- m**
- Mach–Zehnder interferometer 195
 - magnifying glass 152
 - Manley–Rowe relation 466
 - Markov processes 431
 - maser 249
 - natural 249
 - master oscillator power amplifier (MOPA) 349
 - material dispersion parameter 99
 - matrix, lens 20
 - matrix optics 17
 - conventions 18
 - matter waves 187
 - Maxwell–Bloch equations 287
 - Maxwell–Lorentz equations 32
 - Maxwell’s equations 33, 35
 - metal–oxide–semiconductor (MOS) capacitors 375
 - metal-vapour lasers 263
 - metamaterials 143
 - meter, definition 35
 - M^2 factor 348
 - Michelson interferometer 191
 - microchannel plate 370
 - micro-laser 295
 - microscope 154
 - Abbe theory 156
 - cover glass 155, 178
 - resolving power 155
 - microscopy
 - confocal 162
 - scanning near-field optical 162
 - minimum uncertainty states 440
 - mirage 7
 - miser 274
 - mode dispersion 130
 - mode locking 306
 - KLM 310
 - mode matching 203
 - mode pulling 256, 289
 - molecular gas lasers 264
 - Mollow triplet 428, 433
 - momentum, angular 59
 - monochromator 190
 - monolithic miniature laser 274
 - MTF (modulation transfer function) 159
 - Müller matrices 54
 - multimode fibers 130
 - multiple-beam interference 197
- n**
- neodymium
 - amplifier 271
 - quantum states 270
 - neodymium laser 271
 - frequency-doubled 273
 - Newton equation 27, 150
 - nitrogen laser 264
 - noise amplitude 499
 - noise properties of measurable quantities 497
 - nonlinear optical switch 491
 - nonlinear optics, crystal symmetries 461
 - nonlinear polarization 459
 - nonlinear products 459
 - nonlinear Schrödinger equation 103
 - normal dispersion 221
 - number state 439
 - numerical aperture 155
 - optical fiber 13

O

- obliquity factor 65
 - Onsager–Lax theorem 431
 - open quantum systems 426
 - optical angular momentum (OAM) 60
 - optical axis 104
 - optical Bloch equations 232, 236
 - optical cavities 202
 - concentric 207
 - confocal 206
 - damping 202
 - micro- 207
 - modes 203
 - plane parallel 205
 - resonance frequencies 204
 - symmetric 205
 - optical contact 108
 - optical diode 118, 275
 - optical fibers 122
 - optical Fourier transformation 70, 71
 - optical gain 244
 - optical grating 188
 - optical images 149
 - optical isolators 118
 - optical Kerr effect 487
 - optical lithography 158
 - optical mixer 364
 - optical modulators 110
 - optical molasses 398
 - optical parametric oscillator (OPO) 479
 - optical prisms 9
 - optical pumping 224, 229
 - optical resonator, coupling 200
 - optical spectra 428
 - optical spectral analysis 259
 - optical tweezers 403
 - optical wave guides 122
 - oscillator, spectrum 430
 - oscillator strength 228
 - OTF (optical transfer function) 159
- p**
- parabolic mirrors 16
 - parametric fluorescence 445
 - parametric gain 478
 - paraxial approximation 17
 - particle optics 23
 - periodically poled materials 476
 - phase conjugation 491
 - phase-contrast imaging 160
 - phase diffusion 300
 - phase matching 467, 469
 - 90° 471
 - non-critical 471, 472
 - temperature 472
 - types I and II 470
 - phase modulation 111
 - phase noise 298
 - phase, random walk 300
 - phase-sensitive rectification 404
 - phase velocity 34, 98
 - phasor model 300
 - photoactivated localization microscopy (PALM) 165
 - photo-capacitors 375
 - photodiodes 372
 - biased 374
 - operation modes 373
 - photovoltaic 373
 - photon 418
 - photon echo 413
 - photonic bandgap (PBG) 136
 - photonic crystal fiber (PCF) 141
 - photonic crystals 132
 - photonic materials 132
 - photon number distribution 441
 - photon recoil 394
 - photorefraction 278
 - pin diodes 373
 - π pulse 234, 411
 - plasma frequency, metallic 89
 - pn junction 321
 - Pockels cell 306
 - Pockels effect 110
 - Poincaré sphere 53
 - point spread function (PSF) 155, 169
 - polarization 50
 - dielectric 30
 - entanglement 452
 - macroscopic 30
 - microscopic 236
 - polarization-contrast imaging 160
 - polarizers 109

- Porro prism 8
 - position sensors 374
 - power spectral density 499
 - Poynting's theorem 37
 - Poynting vector 37
 - precision measurements 393
 - principal plane 151
 - principal point 27
 - principle of superposition 181
 - prism, minimum deflection
 - angle 9
 - propagation constant 123
 - pseudo spin 231, 234
 - pseudo thermal light 441
 - PSF (point spread function) 159
 - pulse compressor 313
 - pulse distortion 98
 - pulse length–bandwidth product 96
 - pulse propagation 94
 - pulse shaping 95, 113
 - pulse stretcher 313
- q**
- QED (quantum electrodynamics) 219, 417
 - Q factor 286, 382
 - Q-switch 305
 - quadrant detectors 374
 - quadratic index media 129
 - quantities, opto-electronic 357
 - quantum beats 414
 - quantum cascade laser 338
 - quantum confinement 338
 - quantum dots 337
 - quantum efficiency 354
 - quantum electrodynamics (QED) 219, 417
 - quantum electronics 219
 - quantum films 334
 - quantum fluctuations 431
 - quantum optics 219
 - quantum regression theorem 431
 - quantum sensors 353
 - quantum state reduction 422
 - quantum well 336
 - quantum wires 337
 - quasi-phase matching 476
- r**
- Rabi frequency 233
 - single-photon 288
 - Rabi nutation 234
 - Rabi splitting 410
 - radiation formula 240
 - radiation pressure 58
 - radiation reaction 221
 - radiative interaction, semiclassical
 - theory 219
 - rainbow 25
 - Ramsey spectroscopy 404
 - rare-earth ions 269
 - Rayleigh criterion 155
 - Rayleigh scattering 431
 - Rayleigh zone 42
 - ray tracing 151
 - reciprocal lattice 134
 - reference star 169
 - reflection
 - coefficient 85
 - dielectric 84
 - metallic 91
 - reflectivity 86
 - refraction coefficient, nonlinear 487
 - refractive index 3
 - complex 88
 - in conducting materials 89
 - effective 127
 - macroscopic 225
 - table 10
 - refractive power 20
 - relative intensity noise (RIN) 303
 - relaxation
 - longitudinal 236
 - oscillations 292
 - transverse 236
 - repopulation pumping 391
 - reservoirs 426
 - resonance fluorescence 427
 - resonator field, damping 286
 - resonator, unstable 217
 - retarder plates 107
 - zero order 107
 - retro-reflector 8
 - right, left-handed materials 37
 - ring laser 281

- ruby laser 268
- Rydberg constant 392
- S**
- Sagnac interferometer 196
- saturable absorber 310
- saturated gain 289
- saturation intensity 237
- saturation parameter 237
- saturation spectroscopy 388, 390
- scanning near-field optical microscopy (SNOM) 162
- Schawlow–Townes linewidth 258, 304, 341
- Schmidt mirror 174
- Schottky formula 501
- second harmonic generation (SHG) 466
- Seidel aberrations 172
- self-focusing 488
- self-injection locking 344
- self-phase-modulation 494
- Sellmeier equation 9
- semiconductors 319
 - absorption of light 323
 - doped 320
 - emission of light 323
 - optical properties 322
- sensors
 - optical 353
 - quantum efficiency 354
 - sensitivity 354
- shot noise 501
- shot-noise-limited detection 363
- sidebands 112
- signal-to-noise ratio 355
- single lens 24
- single-mode fibers 131
- single molecule detection 164
- single-photon source 445
- skin effect
 - anomalous 90
 - normal 90
- slab laser 273
- SLMs (spatial light modulators) 113
- slowly varying envelope approximation (SVEA) 101
- small signal gain 244
- Snell's law 3
- SNOM (scanning near-field optical microscopy) 162
- solid immersion lens 157
- solid-state lasers 268
- solitons, optical 101
- spatial filter 49, 50
- spatial light modulators (SLMs) 113
- spatial soliton 490
- speckle pattern 214
- spectroscopy, Doppler-free 388
- spherical aberration 173
- spin echo 404
- spontaneous emission 239, 242, 301, 418
 - interpretation 426
 - rate 242
 - suppression 425
- spot diagram 171
- stability criterion 23
- stability diagram 23
- step-index fibers 123
 - HE/EH modes 128
 - LP Modes 128
 - TE/TM modes 127
- stimulated absorption 239, 241
- stimulated emission 239, 241, 292
- stimulated emission depletion (STED) microscopy 165
- Stokes' factor 65
- Stokes matrices 52
- Stokes parameter 52
- strained quantum well 337
- strong coupling 236, 296, 407
- subpixel resolution 376
- sum frequency 477
- superposition principle 33
- superradiance 265
- surface plasmons, surface plasmon polaritons (SPPs), polaritons 92
- SVEA (slowly varying envelope approximation) 101
- T**
- Taylor experiment 188
- tele lens 179

- telescope 166
 - Galilean 166
 - HST 168
 - magnification 167
 - reflector 168
 - resolving power 166
 - temperature, negative 242
 - TE/TM modes 127
 - theory of relativity 34
 - thermal detectors 353, 364
 - thermal field 435
 - thermal lens 488
 - thermal light field 441
 - thermistor 366
 - thermopile 365
 - third harmonic generation 485
 - three-wave mixing 459
 - Ti-sapphire laser 279
 - total internal reflection 87
 - frustrated 88
 - transient phenomena 410
 - transmission 86
 - transmission coefficient 85
 - transverse electric and magnetic (TEM) mode 41
 - transverse relaxation 236
 - triple mirror 8
 - two-level atoms 229, 230
 - two-level laser model 243
 - two-photon spectroscopy 391
 - two-wave polarization 462
 - Tyndall effect 40
- V**
- vacuum fluctuations 421
 - vacuum Rabi frequency 423
 - vacuum Rabi splitting 297
 - velocity of light 34
 - universal constant 34
 - vertical cavity surface-emitting laser (VCSEL) laser 346
 - visibility 184, 430
 - vision distance, standardized 151
 - voltage noise 499
 - V parameter 125
- W**
- walk-off 106
 - wave equation 33
 - with conductivity 89
 - for step-index fibers 123
 - wave front reversal 492
 - wave guides 122
 - absorption 130
 - planar 122
 - polarization maintaining 131
 - single-mode 131
 - weakly guiding 123
 - waves
 - evanescent 88
 - meter 193
 - packet 415
 - planar 37, 39
 - spherical 38
 - Weisskopf–Wigner theory 423
 - Wiener–Khinchin theorem 299, 430, 500
- y**
- Yb laser 278
 - Young’s double-slit 181, 185
- Z**
- zoom lens 179
 - z-scan 488