

Index

A

Aberration

- in interferometers
 - chromatic, 122, 124–125, 147
 - coma, 122, 124
 - gravity induced, 138–140
- in lens for atoms
 - astigmatic, 180
 - chromatic, 180
 - diffusive, 181
 - spherical, 180

ac Stark shift, 281, 286, 368, 377–378, 381–388

Adiabatic

- approximation, 175
- elimination, 259, 377
- rapid passage, 289
- transfer, 381–389. *See also* Dark state
 - ac Stark shifts in, 381–382
 - criterion, 384
 - efficiency, 383
 - in atom interferometer, 385–389
 - intensity sensitivity of, 381–382
 - theory of, 382–385

Aharonov-Bohm effect, 288, 340

- scalar effect, 340, 343

Aharonov-Casher effect, 73, 286, 343

Aliasing. *See* Self-image

Anandan force, 75

Antifringes. *See* Fringes, reversed

Anomalous transmission, 114

Architecture of interferometers. *See*

- Interferometer, architecture of

Argon. *See also* Atomic beam

- level scheme, 87
- transition coupling strengths, 88

Atom grating. *See* Grating, formed by matter wave

Atom interferometer. *See* Interferometer, atom

Atom laser, 205–213, 289

- analogy to thresholdless laser, 211

Bose enhancement factor, 211

comparison with Bose-Einstein condensation, 213

- gain, 207
- mode competition, 211
- photon reabsorption, 213
- threshold behavior, 211
- threshold pump rate, 212

Atom lithography. *See* Lithography, atom

Atom-photon pairs

- correlation. *See* Correlation, atom-photon
- EPR experiments with, 201
- discrete space for, 200
- identification, 199

Atom resonator. *See* Cavity, for matter waves

Atom wave packet

- current, 264
- group velocity, 266

Atomaser. *See* Atom laser

Atomic beam

- brightness of, 124, 141, 144
- deflection due to photon recoil, 37, 57
- laser cooled, 322–326
- of Ar, 88–90
 - detection, 90
- optical pumping, 7, 56
- source
 - coherent, 289
 - for Ar, 89
 - for K, 144, 145
 - for Na, 143, 144
 - for Ne, 153
 - oven, 140, 141, 145
 - supersonic, 5
 - using laser cooling and trapping, 148, 156
 - using velocity selection, 141
- spin polarization, 7
- velocity spread, 31

Atomic clock, 354

Atomic mass measurement. *See* Recoil, shift, measurement of

B

- Beam, atomic. *See* Atomic beam
- Beam combiner. *See also* Interferometer, atom;
 Grating, diffraction, for atoms
 using light, 10, 11, 101, 304
 using mechanical grating, 94, 95, 257
- Beam, molecular. *See* Molecular beam
- Beam splitter for matter waves
 diffractive, 257
 generalized, 257
 using light
 dependence on photon statistics of light,
 106–107
 in Raman-Nath approximation, 309
 off-resonance, 102
 on-resonance, 114
 principle, 297, 301
 pulsed version, 305–307
 running wave field, 262, 296, 301, 304
 standing wave field, 100–103, 195, 296,
 307, 407, 408
 theoretical description, 304–310
 types, 296
 using dark resonance, 296
 using Raman transition, 296
 using mechanical grating, 10, 11, 94, 257,
 408. *See also* Interferometer, atom;
 Grating, diffraction
- Berry's phase. *See* Phase, geometrical
- Blackbody radiation, 335, 356
- Bloch states, 207
- Bordé interferometer. *See* Interferometer,
 Bordé
- Bose-Einstein condensation, 289
- Bragg. *See also* Atom laser
 angle, 258
 condition, 258, 308
 diffraction
 first order, 260
 second order, 260
 scattering of matter waves, 112–117, 413,
 462
 time-dependent, 116

C

- Calcium, 318, 351. *See also* Atomic beam;
 Frequency, standard
 dipole moment, 338
- polarizability, 334
 use in interferometer, 318
- Cascade transition. *See* Three-level system
- Cavity
 for matter waves, 206, 208–210
 loss, 209
 modes, 208–210
 quality factor, 209
- Coherence
 function, transverse
 definition, 191
 measurement of, 192
 length, 31, 32, 302
 of matter waves, 53
 loss due to scattering, 55, 60, 107, 194
 recovery through selective observation, 61
 spin, 240, 243, 245, 247, 248, 249, 251. *See
 also* Interferometer, Stern Gerlach
 criteria for maintenance of, 246–248, 251
 definition, 243, 249
 for arbitrary spin, 249, 250
 loss of, 244, 245, 248, 251
 time dependence of, 245
- Collela, Overhauser, and Werner (COW) type
 experiments. *See* Inertial sensing using
 interferometers
- Collimator, 122–128
 through-put limitation set by, 123
- Complementarity, 218, 219, 222, 232, 253,
 349–351
 and *Welcher Weg* information, 222, 232
 used to explain coherence loss, 53, 56, 222,
 232
- Contrast in matter wave interferometer. *See*
 Interferometer, atom, contrast in
- Contrast interferometry. *See* Interferometry,
 contrast
- Coriolis acceleration. *See* Inertial sensing using
 interferometers
- Correlation
 atom-photon, 190
 first-order, 219
 function
 for single-photon counting, 220, 221, 222
 for two-photon counting, 224
 of signals at different detectors, 223, 224,
 226, 227, 228
 second-order, 218
 two-atom, 164
 intensity of, 164
 spectrum of, 165

Cowley and Moodie. *See* Fourier series, use in Talbot effect
 Curved space-time. *See* Dirac equation

D

Dark state, 384–389. *See also* Adiabatic, transfer
 Delayed choice, 222
 de Broglie
 wave. *See* Matter wave
 wavelength, 125, 138–139, 294, 300
 as function of mass and velocity, 125
 scaling of fringe pattern in Talbot effect with, 125, 133–135
 de Sitter precession, 286
 Differential force interferometry. *See* Interferometry
 Diffraction of matter waves
 Bragg. *See* Bragg, diffraction
 by beam splitter. *See* Beam splitter for matter waves
 dynamical theory of, 113, 262
 Fraunhofer, 122–128, 407, 414, 416, 462
 order, effect of overlapping, 124–126
 Fresnel, 122, 124, 408, 413, 415
 by a finite grating, 131
 Kirchoff integral for, 122, 127, 129, 148–150, 411, 419
 parabolic approximation, 127, 139, 419
 with a spatially-varying potential, 138–139
 pattern, 13, 41, 197. *See also* Interference, pattern
 conditional, 198
 produced by overlap of Fraunhofer orders, 126–129
 visibility, 194
 using light. *See* Beam splitter for matter waves, using light
 using mechanical grating. *See* Beam splitter for matter waves, using mechanical grating
 Diffraction grating. *See* Grating, diffraction
 Dipole force
 induced, 177
 Dipole moment
 electric, measurement of in weak transition, 337
 optical, 304

Dirac equation, 281–284. *See also* Inertial sensing using interferometers
 coupled equations, 283
 curved space-time in, 283
 eight component isospinor in, 283
 generalized connection in, 283
 spinorial connection in, 283
 tetrad field in, 283
 tetrad or *vierbein* in, 283
 theory of gravity in, 284–285
 Doppler
 dephasing-rephasing process, 415, 416, 424, 426, 437
 phase, 411, 415, 426, 440
 shift, 306, 364, 372
 second-order, 306, 326–327
 transverse, 268
 use in selecting cold atoms, 141
 use of in Heisenberg microscope
 decoherence experiment, 145
 Dressed state, 176
 mixing, 234, 237, 239
 Dynamic velocity compression, 148

E

Einstein-Podolsky-Rosen (EPR)
 experiment, with atom-photon pairs, 201
 Electric dipole coupling. *See* Interaction, electric dipole
 Electric dipole interaction. *See* Interaction, electric dipole
 Electric dipole moment. *See* Dipole moment, electric
 Electric polarizability. *See* Polarizability, electric
 Energy-momentum
 balance, 268
 diagrams, 260
 tensor, atomic, 285
 Entangled states, 53, 61, 190, 222, 226
 involving multiple particles, 202
 Greenberger-Horne-Zeilinger state, 204
 Equivalence principle, 286
 and parity, 290
 Eraser, 222, 224, 226, 227
 counts of, 222, 223, 224
 detector for, 223, 224
 photon, 223, 224
 pulse, 222

Eraser (*continued*)

- quantum, 222, 223, 226, 227
 - delayed choice with. *See* Delayed choice
 - using three-level atoms, 222–224
 - using micromaser cavities, 226–228

F

- Feynman path integral. *See* Path integral
- Fine structure constant, 395–398
- Focal plane, 416, 427, 437, 440
 - depth of focus at, 429
- Focusing of atoms. *See* Lens, for atoms, focusing by
- Fourier
 - image. *See* Self-image
 - series expansion, use in Talbot effect
 - for wave amplitude by Cowley and Moodie, 131, 135
 - for wave intensity, 135
 - transform, 135
- Franck-Condon factor, 210
- Fraunhofer diffraction. *See* Diffraction, Fraunhofer
- Frequency
 - measurement, 354
 - standard, 351–358
 - using Ca, 351
 - using Mg, 351
- Fresnel diffraction. *See* Diffraction, Fresnel
- Fresnel-Kirchoff integral. *See* Diffraction, Fresnel, Kirchoff integral for
- Fringes
 - interference, 122, 124, 127–129, 132–135, 138, 141–145, 147. *See also* Diffraction, pattern; Interference, pattern; Interferometer; Phase, shift
 - contrast, 233
 - in separated beam interferometer, 122–123
 - loss of, 219, 220, 222, 226, 228, 231, 232
 - partial, 226, 233, 234
 - quantum vs. classical, 108–112, 413–417
 - Ramsey type, 230, 231, 232, 233, 234, 239, 302, 321, 326–331
 - retrieval of, 222, 224, 228
 - reversed (antifringes), 224, 227, 228

G

- Generalized Talbot effect. *See* Talbot effect
- Generalized Talbot-Lau (GTL) interferometer. *See* Interferometer, Talbot-Lau
- Generalized Talbot-Lau effect. *See* Lau effect
- Geometrical shadow. *See* Grating, diffraction, for atoms, mechanical
- Geometrical phase. *See* Phase, geometrical
- Gori, 131–132
- Gradiometer, gravity, 137, 139, 393–394
- Grating
 - diffraction
 - binary, 130, 131, 135, 136, 137
 - duty cycle of, 22, 422, 443
 - for atoms, 11–12, 22, 24, 26, 121, 122, 123–125, 127–129, 130, 133, 135–137, 139, 140, 141, 143, 145. *See also* Beam splitter for matter waves; Interferometer, atom
 - probe of homogeneity of, 14
 - Ronchi, 130. *See also* Grating, diffraction, binary
 - using light, 10, 121
 - with complex transmission function, 122, 131–133
 - formed by matter wave, 408, 412
 - amplitude of, 408, 416, 417
 - compression of, 429, 451
 - imprinted by mechanical grating, 416
 - of reduced period (higher order grating), 415, 416, 417, 421, 422, 424, 425, 427, 428, 429, 434, 437, 443, 445, 448. *See also* Grating, diffraction
 - symmetry property of, 419, 441
 - using a thermal beam, 453–463
- Gravimeter. *See* Inertial sensing using interferometers
- Gravitational wave, 286
- Gravity. *See* Inertial sensing using interferometers
- Green's function, 148–150
- Greenberger-Horne-Zeilinger (GHZ) state. *See* Entangled state
- Gyroscope. *See* Inertial sensing using interferometers, of rotation ring, using matter waves. *See* Matter waves, using ring gyroscope

H

- Hanbury-Brown Twiss experiment, 164
- Heisenberg microscope, 53
 - decoherence in, 144–147
- Holography, atom
 - binary, 161
 - Fourier, 162

I

- Index of refraction. *See* Matter wave, index of refraction for
- Indistinguishability, of paths, 219
 - and interference, 217–228
- Inertial sensing using interferometers, 65, 75, 93, 98, 110, 346, 347. *See also* Sagnac effect
 - Collela, Overhauser, and Werner (COW) type experiment, 285, 286
 - of acceleration, 24, 66
 - due to gravity, 93, 94, 267, 273, 285, 364, 379–380, 389–392
 - of grating motion, 24
 - of rotation, 24, 66, 93, 94, 286, 379–380, 394–395
- Interaction
 - electric dipole, 260, 282, 283, 366
 - magnetic dipole, 282, 283
 - region, 26
- Interference
 - pattern. *See also* Diffraction, pattern; Fringes, interference
 - in Ramsey interferometer 229, 235, 236, 239
 - in Young's experiment, 221–222, 224, 225, 226
 - retrieval of, 226
 - system-detector correlations, 222, 224, 226
 - using shadow effect, 424–436
 - using Talbot effect, 417–424, 455–457
 - using Talbot-Lau effect, 437–453, 457–461
 - visibility of, 194, 222, 228
 - with two-level atoms, 221
 - with three-level atoms, 222
 - quantum, limits to, 52, 59, 125–126
- Interference filter for atoms, 147
- Interference fringes. *See* Fringes, interference
- Interfering amplitude, 19
- Interferometer
 - atom
 - as state selective detector, 60
 - Bordé type, 277, 287, 296–297, 298, 299, 300–304, 310, 311, 312–331, 339, 351, 386–389
 - contrast in, 19, 21, 23, 24, 26, 29, 32, 37, 53, 56, 60, 315–317
 - generalized Talbot-Lau type, 121–126, 135, 136–137, 140–143, 147–148
 - gravitational effects in, 138–140, 148, 159
 - internal state labeling, 100, 258. *See also* Interferometer, atom, Bordé type
 - MIT, 18
 - Moiré type, 90–99. *See also* Shadow effect; Moiré effect
 - multiple pulses in, 379–381, 387–389
 - sensitivity to external fields, 274
 - separated beam envelope (SBE), 26, 39, 122–124
 - shadow-effect type, 424–436
 - Talbot type, 136, 143–144, 417–424
 - Talbot-Lau type, 437–453
 - through-put of, 123, 124, 141, 143
 - using microfabricated slits, 18–30, 90–99, 287, 407, 408, 414–416, 418, 422, 424, 437, 452, 461, 463
 - using separated light fields, 100–108, 293, 295, 300. *See also* Interferometer, atom, Bordé type
 - using standing-wave fields, 100–108, 407
 - Young's double slit, 158, 407, 410
 - Young's N-slit, 126–129, 133, 147
 - Mach-Zehnder, 18, 299
 - molecule, 28, 278
 - neutron, 257, 287
 - optical, 29
 - Ramsey type
 - general setup, 297
 - two-zone, 276, 278, 286
 - with one micromaser cavity, 234–240
 - with two micromaser cavities, 228–234
 - semi-classical theory of, 20
 - Stern-Gerlach, 240–253, 259, 290
 - control of magnetic field, 241, 243
 - classical limit, 251
 - criteria for, 246–248
 - dispersion of phases, 241, 242
 - Heisenberg equation of motion, 244, 249

Interferometer (*continued*)

- higher-order effects, 248–251
- Larmor angle, 240, 243, 245
- longitudinal, 252–253
- partial beam, 245, 246, 247, 248. *See also*
 - Coherence, spin
 - macroscopic separation, 246
 - microscopic recombination, 247–248
 - scheme of, 240
- white fringe, 19

Interferometry

- contrast, 33, 71
 - applications, 35
 - experimental demonstration, 34
- differential force, 74
- future applications, 71
- matter wave, 2, 9, 18

J

Jaynes-Cummings model, 231, 236, 237

K

Kapitza-Dirac scattering. *See* Scattering
 Kirchoff integral. *See* Diffraction, Fresnel

L

Lamb-Dicke limit, 208

Laser

- atom. *See* Atom laser
- cooling, 156, 396. *See also* Atomic beam,
 - source, using laser cooling and trapping
- phase of. *See* Phase, shift, of laser field
- Larmor angle. *See* Interferometer, Stern-Gerlach
- Lau effect, 124, 125. *See also* Talbot-Lau effect;
 - Interferometer, generalized Talbot-Lau
- experiment using, 130, 135

Lens,

- elimination of in GTL interferometer, 122,
 - 136–137
- for atoms
 - achromatic, 182, 183, 185
 - applications, 188
 - focusing by, 177, 179. *See* Aberration, in
 - lens for atoms

thick, 179

thin, 178

use in Lau effect, 136

use in Talbot effect, 130

use in Talbot interferometer, 122, 136

Lense-Thirring effect, 286

Light shift. *See* ac Stark shift

Light crystals. *See* Optical lattices

Lithography, atom, 188, 414, 429, 463

sources for, 181

M

Mach-Zehnder interferometer. *See*

Interferometer, Mach-Zehnder

Magnesium, 318, 351

polarizability, 334

use in interferometer, 318. *See also* Atomic

- beam; Frequency, standard

Matter wave

- birefringence and dichroism for, 290
- index of refraction for, 31, 42, 71, 276
 - attenuation associated with, 43
 - for molecules, 50
 - in an atomic cloud, 289
- phase shift, 43
- measurement, 45
- role of collision partner, 49
- sensitivity to shape of long range potential,
 - 47
 - theoretical analysis, 47
- interference. *See* Interferometer, atom
- interferometer, 294, 349
 - history of, 294
 - thermal source for, 312. *See also*
 - Interferometer, atom
- polarized, optically active molecules
 - circular dichroism of, 290
 - rotary power of, 290
- red shift effects, 283
- ring gyroscope using, 289
- Micromaser, 218, 219, 225, 226, 227, 228, 229,
 - 230, 232, 234, 235, 236, 237
 - as part of Ramsey interferometer, 219, 228,
 - 229, 230
 - as *Welcher Weg* detector, 225, 226, 227, 228,
 - 231, 232
- atom-field interaction in, 230
- density of modes in, 229, 230

- Ramsey fringes for,
 - with one cavity, 234, 235, 236, 237, 239
 - with two cavities, 230, 231
- Microscope. *See* Heisenberg microscope
- Microwave spectroscopy, 297
- Mode selection. *See* Cavity, for matter waves
- Mode matching. *See* Cavity, for matter waves
- Mode volume. *See* Cavity, for matter waves
- Moiré effect, 91, 122, 130, 137, 141–142. *See also* Interferometer, atom, moiré type; Shadow effect
- Momentum
 - basis. *See* Quantum, treatment of center-of-mass motion
 - distribution, after spontaneous emission, 192. *See also* Coherence, of matter waves, loss due to scattering
 - conditional, 201
- Multiple pulses. *See* Interferometer, atom, multiple pulses in

N

- Neon. *See also* Atomic beam
 - level scheme, 153, 154, 163
 - lifetime of levels in, 155

O

- Optical dipole moment. *See* Dipole moment
- Optical frequency measurement. *See* Frequency, measurement
- Optical frequency standard. *See* Frequency, standard
- Optical lattice, 112, 206
- Orthogonality, of final (detector) states, 226, 227, 228
 - versus position-momentum uncertainty relation, 228

P

- Paraxial approximation, 175. *See also* Diffraction, Fresnel, parabolic approximation

- Path-integral, 138–140, 149–150, 310
- Pendellösung*, 264, 306
- Phase
 - Doppler. *See* Doppler, phase
 - geometrical, 72, 339. *See also* Aharonov-Bohm effect; Aharonov-Casher effect
 - grating; Beam splitter for matter waves, using light, off-resonance
 - object, 196
 - of laser field, 302
 - shift, 274, 285, 370, 374, 377–378, 380, 390–392, 399–400. *See also* Fringes, interference
 - averaging, 32
 - best achievable resolution, 92
 - dispersive, 222, 228, 241, 242, 339
 - due to acceleration/rotation. *See* Inertial sensing using interferometers; Sagnac effect
 - due to applied potential, 27, 30, 311, 331–338
 - due to atom-gas scattering, 42
 - due to atom-photon scattering, 55
 - dynamical, 302
 - from partial wave expansion, 49
 - function of path separation, 56
 - minimal detectable, 289
 - nondispersive, 339
 - readout of, 399–400
 - uncontrolled. *See* Phase, shift, dispersive
 - velocity dependence, 31, 32, 39, 66, 73
 - versus envelope shift, 111
- Photon-atom scattering inside interferometer. *See* Scattering, photon-atom
- Photon recoil shift. *See* Recoil, shift
- Polarizability, electric
 - of atoms, 331–335
 - of Na, 39
 - experimental parameters for, 40
 - of Na₂, 71
 - phase shift in interferometer produced by. *See* Phase, shift, due to potential
- Ponderomotive potential, 177
- Potential measurement. *See* Phase, shift, due to potential
- Propagator, free, 270
- Pulsed interferometer. *See* Interferometer, atom, Bordé type

Q

Quantum
 channeling, 113
 computing, 133, 148
 dots. *See* optical lattice
 eraser. *See* Eraser
 treatment of center of mass motion, 51,
 371–372, 408
 vs classical fringes. *See* Fringes, interference
 Quality factor. *See* Cavity, for matter waves

R

Rabi
 formula, 366–370
 frequency, 175, 176, 304, 366, 368, 370,
 375–379
 effective two-photon, 384
 oscillations, 264
 exciting atom with a single photon, 56
 observation using momentum transfer, 15
 Raman pulse sequence, 375–379
 Raman transition. *See* Three-level system,
 folded
 Raman-Nath regime. *See* Scattering
 Ramsey fringes. *See* Fringes, Ramsey type
 Ramsey-Bordé interferometer. *See*
 Interferometer, atom, Bordé type
 Ramsey interferometer. *See* Interferometer,
 Ramsey type
 Recoil
 effect, 411, 412, 417, 437, 462
 shift, 268, 285, 302
 measurement of, 279, 395–398, 403
 optimization of, 279
 splitting, 303, 321, 326–333
 of Lamb dip, 412
 of Ramsey fringes, 412
 suppression of, 329
 Recoiling slit, *gedanken* experiment, 198
 Relativistic effects in electromagnetic
 interactions, 73
 Rotating frame transformation, 367
 Rotating wave approximation, 174, 367
 Rydberg atom
 in micromaser Ramsey interferometer, 228,
 230
 in Young's double slit experiment, 225
 interaction with micromaser cavity, 230

S

S matrix. *See* Scattering, matrix
 Sagnac effect, 66, 110, 142–143, 283, 286, 287,
 288. *See also* Inertial sensing using
 interferometers, of rotation
 measurement of, 75, 94, 110, 346–349
 using atom interferometer, 68, 110
 using Cs interferometer, 75
 using moiré interferometer, 94
 reproducibility in, 68
 velocity dependence, 66
 Scalar Aharonov-Bohm effect. *See* Aharonov-
 Bohm effect
 Scattering
 forward amplitude for, 43
 derivation of, 47–48
 ratio of real to imaginary parts, 43
 glory oscillations in, 49
 inelastic vs elastic, 267
 Kapitza-Dirac, 309, 412
 matrix, 270
 in two-beam approximation, 271
 photon-atom, inside interferometer
 coherence loss, 54
 contrast recovery, 62
 contrast revivals, 57
 direction of scattered photon, 61
 effects, 55, 57
 using two interferometers, 63. *See also*
 Coherence, of matter waves, loss due
 to scattering; Fringes, interference
 Raman-Nath regime, 179
 Second order Doppler shift. *See* Doppler, shift
 Self-image, 122, 130–133. *See also* Fringes,
 interference; Talbot effect
 filtered, 132–133, 135
 Fourier, 122, 131–133
 Fresnel, 122, 131, 133
 multiple aliasing of, 122, 131, 133–135
 Separated beam envelope (SBE) interferometer.
See Interferometer, atom
 Separated light fields. *See* Interferometer, atom
 Shadow effect, 409, 415, 424, 437, 441, 443,
 450, 452. *See also* Grating, formed by
 matter wave; Grating, diffraction, for
 atoms; Interferometer, atom, shadow type
 comparison with Talbot-Lau effect, 437, 440,
 441, 452
 difference from matter-wave interference, 410
 geometrical interpretation, 424

- of background-free gratings, 435
- of loss of pattern, 435
- using incoherent light, 425
- Signal to noise optimization, 22, 67
- Source. *See* Atomic beam
- Spin coherence. *See* Coherence
- Spin-rotation coupling, 283, 286
- Spontaneous emission
 - coefficient, of a laser, 210
 - inside an interferometer. *See* Coherence, of matter waves, loss due to scattering
 - single, 190
- Stark effect, 332–337
- Stern-Gerlach
 - apparatus, 241–243
 - effect, optical, 175
 - interferometer. *See* Interferometer scheme, 242
- Stuckelberg angle, 176
- Surface probes, 188

T

- Talbot distance, 14, 52, 411. *See also* Talbot-Rayleigh wavelength
 - for collimated beam, 419
 - for divergent beam, 437, 441, 451
- Talbot effect. *See also* Self-image; Interferometer, Talbot type; Grating, atom, of reduced period
 - for matter waves, 15, 122, 124, 126, 130–132, 411, 413, 414, 417
 - application to lithography, 15
 - comparison with Talbot-Lau effect, 136, 451
 - consequence of atomic recoil, 412, 417
 - experiment, 130–131
 - fringes, 124, 141
 - generalized, 130–135
 - number theory in Talbot effect, 133, 147
 - resonance in, 125–126, 131–132, 133–135, 137, 141, 143–144, 147
 - temporal, 137
 - using thermal beam, 453, 455
- optical, 14, 411, 419
- Talbot phase, 411, 414, 418, 441, 452
 - averaging over in thermal beam, 454
- Talbot-Lau effect. *See also* Lau effect; Interferometer, atom, generalized Talbot-Lau type

- atomic
 - as generalization of shadow effect, 416
 - caused by matter-wave interference only, 452
 - in a thermal beam, 453, 460, 461
- optical, 414, 416
- Talbot-Rayleigh wavelength. *See* Wavelength
- Telltale photon, 225
- Thomas precession, 284, 285
- Three-level system
 - cascade, 260, 261
 - folded, 260, 261
- Through-put of interferometer. *See* Interferometer, atom
- Time domain interference. *See* Interferometer, atom, Bordé
- Topological phase. *See* Phase, geometrical
- Trap
 - magnetic, 157
 - magneto-optical trap (MOT), 148, 323
 - optical, 368
- Trapped atoms, 319, 324
- Two-level approximation, 174

U

- Uncertainty, position-momentum, 222, 228, 242
 - phase dispersion in, 242

V

- Visibility of atom interference pattern. *See* Interference
- Vacuum system, 4
 - differential pumping, 5
 - vibration isolation, 5
- Velocity multiplexing, 37, 71
- Vibration
 - cause of contrast reduction, 24
 - isolation, 396–397, 400–404
 - observed in interferometer, 26
 - reduction, 25
- Virtual slits, 202

W

- Wavelength
 - de Broglie, 125, 138–139
 - as function of species mass and velocity, 125

Wavelength (*continued*)

scaling of fringe pattern in Talbot effect
with, 125, 133–135

Talbot-Rayleigh, 127–129, 132–135. *See also* Talbot distance

Welcher Weg, 53, 56

detector, 222, 225, 226, 227, 232. *See also*
Welcher Weg, information

information, 193, 218, 220, 222–226, 228,
231, 232–234

and complementarity, 222, 232

and loss of interference, 220, 222, 224,
228, 231, 232

experiment, 350

in diffraction, 106–108

in interferometer, 105

partial, 233, 234

role of momentum recoil, 226

with three-level atoms, 219–222

with micromaser cavities, 225–228,
231–234

Which way information. *See Welcher Weg*

Wigner distribution function

free evolution, 439

jumps of on microfabricated structures,
438

Wigner-Weisskopf approximation

for light scattering from trapped atoms,
221

Y

Young's double-slit experiment, 218, 219, 221,
224, 225, 231. *See also* Interferometer,
atom

by scattering light from two atoms in a trap,
219–224

with micromaser *Welcher Weg* detector,
224–228

Young's N-slit interferometer. *See*
Interferometer, atom