

Index

- aberrations
 - chromatic, 39
 - in stretcher, 40
 - optical, 38
 - wavefront, 53, 62
- ablation
 - plasma density, 694
 - pressure, 693
- above-threshold dissociation, 307
- above-threshold ionization, 3, 167, 223, 307, 317, 323, 499
 - angular distributions, 223, 239, 246, 259
 - by few-cycle pulses, 244
 - carrier envelope phase effects, 244
 - critical intensity for onset of nonperturbative character, 230
 - cutoff, 237
 - ellipticity effects, 240
 - Freeman resonance, 233
 - from tunneling, 234
 - heating, 499
 - in molecules, 281
 - nonperturbative, 224, 230
 - peak suppression, 230, 231
 - perturbative, 226
 - plateau, 225, 237
 - quasi-classical, 234
 - rescattering effects, 225, 236
 - resonant enhancement, 232
 - strong field approximation, 223, 238
- absorption
 - at a plasma surface, 662, 667, 709
 - atomic, 140, 147, 326, 375
 - Brunel. *See* vacuum heating
 - collisional. *See also* inverse bremsstrahlung heating. *See* inverse bremsstrahlung heating 501
 - collisional at sharp interface, 691
 - collisionless, 659, 672, 675, 685, 703, 708
 - fraction, 715
 - in the continuum, 235
 - multiphoton, 144, 149, 170, 180, 204, 223
 - nonthermal, 688
 - of circularly polarized light, 240
 - photoionization, 356, 375
 - resonance. *See* resonance absorption
 - thermal, 688
 - two-photon, 149
- accelerated frame. *See* Kramers–Henneberger frame
- accelerated mirror model, 765
- acceleration
 - beam loading effects, 642
 - beatwave, 632
 - blow-out regime, 626
 - bubble, 6, 626, 638, 642
 - direct laser, 655
 - electron, 562, 609
 - electron injection seeding, 635
 - hydrodynamic expansion, 754
 - ion, 703, 754
 - photon, 587
 - radiation pressure, 765
 - target normal sheath, 8, 743, 755, 756, 767, 770, 787
 - wakefield, 6, 610, 621, 624
 - wakefield, maximum energy gain, 618
- acousto-optic
 - modulation, 29
 - programmable dispersive filters, 46
- action
 - quasi-classical, 332, 336, 338, 348
- adaptive optics, 65
- adiabatic
 - curve, 302, 307
 - evolution of pendular states, 285
 - expansion, 391, 463, 468, 663
 - limit, 184
 - limit for molecular alignment, 284
 - limit in a cluster, 427
 - sound speed, 467
 - stabilization, 249, 252, 258

- states, 300, 301, 304
- adiabatically
 - varying field, 142
- adiabaticity
 - electron in a field, 237
 - of electron oscillations, 75, 87, 501, 577, 714, 728
- ADK formula. *See* PPT/ADK formula
- Airy function, 680, 683, 712
- Airy pattern, 63
- Akheizer–Polovin equations, 547
- alexandrite, 22
- alignment
 - molecular, 274, 283, 310, 348
 - transient, 288
- ambipolar
 - potential, 672
 - sheath field, 464, 669, 671, 777
- Ammosov–Delone–Krainov formula. *See* PPT/ADK formula
- Ampere’s law, 496, 548, 628, 676, 679, 681, 684, 722, 752, 779
- amplified spontaneous emission, 27, 58
- amplitude modulation, 589
- anharmonic
 - damping, 438
 - dipoles, 318
 - motion, 71, 83, 92, 97
 - potential, 453
- anharmonic motion, 316
- anomalous skin effect, 727
- anti-Stokes wave, 591
- ASE. *See* amplified spontaneous emission
- ATD. *See* above-threshold dissociation
- ATI. *See* above-threshold ionization
- atomic photoionization. *See* ionization, photoionization
- atomic unit
 - electric field, 2, 142, 153
 - frequency, 153
 - intensity, 153
- atto-chirp. *See* attosecond pulse, attochirp
- attosecond pulse
 - lighthouse*, 389
 - atto-chirp, 378
 - atto-pulse spacing, 383
 - generation, 5, 376
 - polarization gating, 387
 - single pulse generation, 385
 - temporal gating, 385
 - trains, 377
- Atwood number, 769
- avoided crossing, 301
- backscatter
 - Raman, 596
- barrier suppression ionization. *See* ionization, barrier suppression
- BBO. *See* beta-barium borate
- beam loading, 642
- beam quality, 21, 41, 50, 65
- beatwave acceleration. *See* acceleration, beatwave
- Bebb and Gold, method, 157, 242, 246
- Beg formula, 733, 737, 743, 757, 763
- benzene, 280
- beta-barium borate, 24, 35, 62
- betatron
 - electron trajectory, 644
 - oscillations, 643
 - radiation emission, 7, 648
 - resonance, 655
 - X-ray properties, 652
- Bethe–Heitler process, 746
- B*-integral, 20, 55, 59, 62
- Bloch equations, 163
- blow-off plasma, 668, 777
- blow-out regime, 626
- blue shift
 - ionization-induced, 535, 584
 - relativistic, 586
- Bohm–Gross frequency, 594
- Bohr radius, 144, 153, 187, 212
- Boltzmann
 - distribution, 758, 760
 - statistics, 761
- bond hardening, 309
- bond softening, 5, 273, 303, 311
- Born approximation, 151, 255
- Born–Oppenheimer approximation, 268, 292, 303
- Breizman–Arefiev model, 424, 429
- bremsstrahlung
 - inverse. *See* ierse bremsstrahlung heating, 501
 - X-rays, 660, 746, 774, 785
- Brunel absorption/heating. *See* vacuum heating
- BSI. *See* ionization, barrier suppression
- bubble acceleration. *See* acceleration, bubble
- canonical momentum, 73
 - conservation, 78, 85, 110, 121, 131, 549
- carrier envelope phase, 245
 - control, 32
- cavitation
 - electron plasma, 535, 562, 564
 - ion, 576
- CEP. *See* carrier envelope phase channel
- channel
 - electron plasma, 564
 - oscillation, 567
- channel closing, 180, 231
- channel, ion, 576
- charge resonant enhanced ionization. *See* critical ionization distance, molecules
- chirped pulse amplification, 4, 13
- cluster, 6
 - Coulomb explosion. *See* Coulomb, explosion
 - formation in gas jets, 390
 - nanoplasma, 393

- CO₂ laser, 67
- coherence length, 360, 373, 375
- coherent transition radiation, 743
- coherent wake emission, 747
- colliding pulse injection, 640
- collision
 - Coulomb, 449, 501, 504
 - electron–ion, 449, 453, 497
 - frequency, 496, 497, 505, 692
 - frequency, electron–ion, 449, 496, 503, 504, 594
 - term, 501
- collisional
 - absorption, 688
 - damping, 399, 457, 486, 496, 594, 685
 - damping, in cluster, 449
 - equilibration time, electron–ion, 499
 - excitation, 214
 - ionization. *See* ionization, collisional
 - ionization, in cluster, 415
 - plasma, 450, 497
- collisional absorption. *See* absorption, collisional, 672
- collisionality, 709
- collisionless
 - absorption, 688, 708, 710
 - damping, 594
 - skin depth, 678
- collisionless damping
 - cluster, 450
 - frequency, 452
- collisionless scattering, 453
- compressor. *See* pulse compressor
- conductivity
 - effect on magnetic field generation, 779
 - electrical, 737, 738, 741
 - thermal, 663
- continuity equation, 548, 559, 568, 582, 592, 601, 671, 674, 698, 740
- continuum lowering, 404, 408, 416
- continuum state, 145, 154, 170, 228, 255
- contrast
 - temporal pulse, 57
- Coulomb
 - collision, 237, 504, 737
 - continuum state, 156
 - correction, 194, 199, 264
 - explosion, 5, 577
 - explosion time, 310
 - explosion, cluster, 396, 435, 471, 477, 478
 - explosion, ion channel, 576
 - explosion, molecular, 309, 314
 - focusing, 211, 259
 - force, 169
 - force neglect in the strong field approximation, 170
 - gauge, 72, 293, 548
 - logarithm, 418, 433, 506, 663
 - potential distortion in laser field, 183, 200, 274
 - pressure, 476
 - scattering, 237, 248, 436, 449, 450, 453, 501, 505, 509
 - scattering cross section, 505
- CPA. *See* chirped pulse amplification
- Cr:LiSAF, 22
- critical density, 495, 662
- critical ionization distance, 5, 310
- cluster, 408
 - molecule, 273, 311
- critical power. *See* self-focusing, critical power
- critical radius, 577
- critical radius, electron cavitation, 577
- cross-polarized wave generation, 60
- CTR. *See* coherent transition radiation
- cutoff law, high harmonic, 318, 323, 324, 326
- Debye
 - cloud, 395, 406
 - length, 405, 506, 729, 761
 - radius, 395
 - sheath, 395, 757
 - shielding, 404
- defocusing
 - ionization-induced, 515
- deformable mirror, 65
- density of states, 134, 151
- density profile modification. *See* ponderomotive, steepening
- density ramp injection, 640
- dephasing length
 - in wakefield acceleration, 619
- diabatic
 - curve, 302
 - states, 300, 304
- dielectric
 - constant, 495, 498
 - effective, angle-dependent, 686
 - function, 686
 - function, complex, 692
 - function, complex optical, 497
 - function, plasma, 675
 - function, plasma in density gradient, 712
 - function, plasma optical, 503, 685
 - function, plasma profile, 679
- diffraction limit, 53, 63
- diffusivity, thermal, 664
- dipole approximation, 137, 144, 168, 174
- dipole moment
 - molecular, 284
- dipole resonance. *See* giant dipole resonance
- direct laser acceleration. *See* acceleration, direct laser
- dispersion, 41
 - compensation, 27, 41
 - group-delay, 43
 - stretcher, 45
 - third-order, 43, 46
- dispersion relation, 592
- DLA. *See* acceleration, direct laser

850

Index

- Doppler shift, 93, 97, 597, 701, 703, 748
- double ionization. *See* ionization, nonsequential
 - double
- dressed states, 298, 306
- drift velocity
 - electron, 77, 78, 234
 - electron longitudinal, 83, 86, 94, 98, 126
- Drude model, 371, 402, 536, 686
- dye laser, 68
- dynamic localization, 262

- ECI. *See* ionization, collisional
- effective principal quantum number, 198
- electromagnetic pulse generation, 784
- ellipticity. *See* polarization, ellipticity
 - effect on high harmonics, 324
- ellipticity. *See* polarization, ellipticity
- emittance, electron beam, 132, 630
- EMP. *See* electromagnetic pulse generation
- EOS. *See* equation of state
- equation of state
 - ideal gas, 465, 468, 581, 594, 670, 777
- etching, laser pulse, 608
- Euler–Lagrange equations, 74, 80
- evolution operator, 146
- excimer laser, 23

- Faraday’s law, 561, 675, 687, 738, 776, 779
- fast ignition, 7, 787
- Fermi’s golden rule, 140, 147
- figure-8 motion, 96, 720, 725
- filamentation
 - laser in air, 7, 524
 - length, 529
- fission, photo, 785
- flashlamp pumping, 19, 22, 48, 67
- Floquet
 - adiabatic states, 304
 - Fourier component, 297
 - Hamiltonian, 294, 296, 300
 - quasi-energies, 295
 - state, 296, 298, 301
 - theory, 292
 - theory for two-level system, 299
 - theory of bonds in a strong field, 303
- fluid equations, 548, 568, 752
- Franck–Condon factors, 267, 282
- free-streaming. *See* ionization, free-streaming
- Freeman resonance, 233, 240
- Fresnel equations, 691
- fusion
 - in cluster plasmas, 6, 493
 - inertial confinement, 787

- gain narrowing, 15, 21, 27, 48, 53
- gain saturation, 53
- gas jet, 390, 490, 494

- gauge
 - Coulomb, 72, 137
 - length, 139
 - radiation, 72, 137
 - transformation, 137
 - velocity, 172
- gauge invariance, in strong field approximation, 168
- Gauss’s law, 496, 555, 613, 621, 628, 682, 700, 704, 726
- Gaussian beam, 111, 512, 519, 525, 541, 565
 - effective beam area, 526
 - focus, 126, 219
 - longitudinal fields in focus, 115
 - refraction, 512
- Gaussian pulse shape, 75, 88, 244
- generalized Bessel function, 172
- gerade symmetry, 254
- giant dipole resonance, 398, 402, 434, 438
- Gouy phase shift, 352, 357, 360
- grating, 8, 14, 23, 35
 - equation, 37, 45
 - fiber Bragg, 31
 - gold, 41
 - in stretcher, 38
- Green’s function, 556, 569
- group delay dispersion, 41
- group velocity, in plasma, 498

- Hagena parameter, 391
- Haines hot electron conversion law, 734
- Hamiltonian, 73, 137, 283, 288
 - Floquet, 294
 - interaction, 137, 144, 146, 238, 293
 - interaction operators, 148
 - interaction, velocity form, 171
 - Kramers–Henneberger, 249
 - length form, 137, 144, 167
 - molecular rotational, 285
 - relativistic, 80
- harmonic oscillator
 - plasma wave, 569
- heat capacity
 - plasma. *See* specific heat
- heat conduction, 663
- heat equation, 664, 668
- Helmholtz equation, 556, 677, 679, 696
- thermal velocity, 452
- Hermitian, matrix, 298
- HHG. *See* high-harmonic generation
- high harmonic chirp, 383
- high harmonic cutoff law, 326
- high-harmonic generation, 4, 316
 - ellipticity effects, 344
 - from solids, 747
 - in molecules, 348
 - phase-matching, 350
 - single-atom model, 321
 - three-step model, 324

- highest occupied molecular orbital, 264, 270
 hole boring, 699, 709, 713
 relativistic intensity, 701
 surface velocity, 701
 HOMO. *See* highest occupied molecular orbital
 hot electron
 generation, 660. *See also* collisionless, absorption, 733
 production, 7
 recirculation, 764
 temperature, 672, 713, 733
 transport, 736
 hydrodynamic expansion, 659, 668, 693, 696
 cluster, 463
 two-electron temperature, 672
- IFA. *See* ionization, tunneling, ion-field assisted
 inelastic excitation, 214
 intensity
 relativistic, 1
 inverse bremsstrahlung heating, 499, 501, 594, 688
 in finite scale length, 688
 inverse Compton scattering, 128
 ion acceleration. *See* acceleration, ion
 ion acoustic waves, 576
 ion temperature, 499, 581
 ion-field assisted tunneling. *See* ionization, tunneling, ion-field assisted
 ionization
 absorption in a filament, 529
 avalanche, 661
 average state, 663
 barrier suppression, 518
 barrier suppression, 200
 collective tunneling, 206
 collisional, 212, 499, 659, 661
 collisional, cross section, 212
 evaporative, 430
 free-streaming, 430
 ignition, 418
 impact, 487
 injection, 640
 knee structure, 222
 multiphoton. *See* multiphoton ionization
 nonsequential double, 204
 photoionization, 140, 206, 256, 356, 375
 polyatomic molecule, 279
 potential, 140, 264, 266, 268, 274, 303, 518
 saturation, 180, 212, 418
 sequential, 141
 SFA rate in tunneling limit, 193
 shake-off, 206
 stabilization, 248
 state, 496, 516, 518, 585
 time-dependent, 511
 tunnel, 142, 498, 499, 518
 tunneling, 4, 143, 167, 183, 184, 205, 212, 323, 345, 361, 378
 tunneling in circular polarization, 203
 tunneling in complex atoms, 196
 tunneling in hydrogen atom, 186
 tunneling, Coulomb correction, 194
 tunneling, cycle-averaged, 191
 tunneling, in clusters, 408
 tunneling, in molecules, 262, 268, 348
 tunneling, ion-field assisted, 408
 tunneling, molecular, 263
 tunneling, relativistic correction, 260
 ionization-induced plasma defocusing, 515
 isothermal
 expansion, 759
 sound speed, 470, 583, 662, 670
- $J \times B$ heating, 720
 Jacobi–Anger formula, 105, 171
- KDP. *See* potassium dihydrogen phosphate
 Keldysh
 approximation, 167, 238
 parameter, 185, 207, 234, 247, 268, 341
 Keldysh–Faisal–Reiss theory. *See* strong field approximation
 Kepler’s third law, 443
 Kerr effect, 60, 67
 Kerr-lens mode-locking, 30
 KFR theory. *See* strong field approximation
 KH frame. *See* Kramers–Henneberger, potential
 kinetic equation, 501, 548
 Krainov–Smirnov model, 427
 Kramers–Henneberger
 ground state wavefunction, 252
 Hamiltonian, 249
 potential, 251
 KrF laser, 23
 Kummer confluent hypergeometric function, 156
- L’Hospital’s rule, 623
 Lagrangian, 72
 cyclic variables, 74, 77
 relativistic, 79
 Landau damping, 594, 685
 Landau–Zener theory, 302
 Langmuir wave, 711
 Laplace’s Method, 414
 Larmor
 formula, 91, 109, 318
 Larmor formula, 91
 laser energy bunching, 589
 laser plasma instabilities, 590
 in plasma density gradients, 730
 LBO. *See* lithium triborate
 LCAO. *See* linear combination of atomic orbitals
 Lewenstein model. *See also* strong field approximation, high-harmonic generation, 330
 Liénard–Wiechert potentials, 100

- light pressure. *See* pressure, light
 linear combination of atomic orbitals, 264
 lithium triborate, 25, 68
 Littrow angle, 37, 45
 localization
 electron in molecular tunneling, 276
 longitudinal fields
 effect on ponderomotive scattering, 118
 in focus, 114
 LOPT. *See* lowest-order perturbation theory
 Lorentz
 factor, 108
 frame, 80
 invariant, 95, 134, 648
 transform, 93, 98, 128, 135
 Lotz formula, 415
 lowest-order perturbation theory, 3, 4, 143, 144, 156,
 180. *See also* multiphoton ionization, 263
 breakdown, 164
 intensity validity range, 152
 multiphoton cross section, 154
 relation to the strong field approximation, 167
 LPI. *See* laser plasma instabilities
- magnetic field generation, 775
 Maxwell's equations, 115, 117, 496
 Maxwellian
 distribution, 500, 508
 Mie
 resonance, 398, 400, 408, 419, 438, 441, 445, 451,
 453, 483
 resonance, at relativistic intensity, 448
 resonance, with large amplitude electron
 oscillation, 443
 scattering, 399
 mode-locking, 27
 molecular
 alignment, 303
 bond, 303
 bond hardening, 308
 MPI. *See* multiphoton ionization multielectron atoms
 multielectron atoms
 multiple ionization, 216
 multielectron effects, molecular, 6, 271
 multiphoton ionization, 3, 143, 498, 527, 660
 above-threshold ionization regime, 224
 cross section, 152, 154
 diatomic molecules, 263
 diatomic molecules, vibrational excitation, 267
 hydrogen molecule, 282
 perturbation expansion, 144
 resonantly enhanced, 158
 resonantly enhanced, in ATI, 233
 transition rate, 149
 multiphoton process, 321
 multiphoton processes, 142
 multiple ionization, 204
- nanoplasma, 6, 395, 398, 403, 408, 424, 440, 457,
 463, 483
 heating, 434, 456
 nanoplasma model, 390, 393, 400, 402, 404, 415, 441
 Nd:glass, 15, 19
 Nd:YAG, 67
 NDSI. *See* ionization, nonsequential double
 neutron production
 by laser-driven ion acceleration, 770
 cross sections, 770
 nonlinear refractive index, 56, 524
 nonlinear Thomson scattering
 angular distribution, 100
 nonperturbative
 nonlinear optics, 4
 nonperturbative effects, 2, 3, 166, 167, 234
 nonsequential double ionization, 5, 204
 Coulomb focusing effect, 211
 inelastic excitation, 214
 recollision dynamics, 207
 wavepacket spreading, 211
 normalized vector potential, 79, 82, 94
 definition, 548
 NSDI. *See* nonsequential double ionization
- Offner triplet, 40
 Ohm's law, 738
 OPCPA. *See* optical parametric chirped pulse
 amplification
 optical parametric chirped pulse amplification, 15, 24
 nanosecond, 21
 picosecond, 61
 with Nd
 glass amplifiers, 21
 orbital
 molecular, 263, 264
 antibonding, 264, 265
 atomic, 264
 bonding, 265
 molecular, 6
 pi, 269
 organic molecule, 263, 280
 oscillating mirror model, 748
 over the barrier ionization. *See* ionization, barrier
 suppression
 overdense plasma, 659, 692, 710, 715
- pair production, 746
 parabolic coordinates, 187, 196
 paraxial wave equation. *See* wave equation, paraxial
 Parseval's theorem, 101
 partition function
 rotational, 287
 pendular states, 284
 perturbation
 expansion, 146
 theory, 140, 143

- theory breakdown, 1, 153
- phase control, CPA, 41
- phase velocity, 511
 - light in plasma, 498, 511, 516
 - plasma wave, 539
- phase-matching, 320
- phase-matching, in high-harmonic generation, 350
- photoelectric effect, 140
- photoionization. *See* ionization, photoionization
- photon acceleration. *See* acceleration, photon
- plasma frequency, 398, 402, 495, 549, 588, 590, 597, 616, 676, 747
 - relativistic, 536, 604
- plasma wave
 - nonlinear, 547
- plasma wave, electron, 511
- plateau, high-order harmonic, 4, 317, 321, 323, 328, 336, 346, 349, 362, 378
- Poisson's equation, 548, 549, 558, 560, 563, 569, 577, 593, 601, 615, 616, 629, 722, 752, 760
- polar moment of inertia, 289
- polarizability
 - atomic, 391
- polarization
 - atomic, 316, 319, 354, 361, 527
 - circular, 77, 96, 203, 500, 601, 720, 767
 - cluster, 445, 480
 - effects in HHG selection rules, 322
 - elliptically, 727
 - elliptical, 721
 - ellipticity, 278, 333
 - ellipticity effects on high-harmonic generation, 344
 - gating, 387
 - laser, 71, 75, 82, 86, 90, 92, 102, 114, 127, 137, 263, 269, 280, 283, 284, 288, 292, 303, 331, 348, 388, 399, 408, 410, 427, 462, 480, 482, 501, 600, 655, 781
 - molecular, 280, 591
 - P-polarization, 682, 688, 692, 709, 720, 747
 - S-polarization, 686, 692, 720
 - scattered emission, 102
 - Stokes wave, 595
 - surface, 743
 - surface high harmonic, 753
- pole approximation, 229
- polyatomic molecule, 279, 280
 - Coulomb explosion, 314
- ponderomotive
 - channeling, 564
 - continuum energy shift, 174, 226, 232, 282
 - driven electron current, 776–778
 - ejection from focus, 118, 226, 231, 260, 539, 564
 - electron density driven motion, 537
 - electron expulsion, 564, 570, 575, 626, 628, 638
 - electron injection, 581
 - energy, 76, 78, 85, 139, 170, 175, 210, 224, 231, 237, 243, 303, 326, 394, 456, 499, 509, 588, 604, 719
 - energy compared to thermal, 501
 - energy gradient, 114, 546
 - energy level shift, 160, 282, 293
 - energy modulation, 599
 - energy of cluster electron cloud, 416
 - energy phase shift in high-harmonic generation, 363
 - force, 111, 124, 535, 539, 553, 554, 560, 565, 569, 577, 581, 639, 692, 695, 697, 721
 - force approximation breakdown, 124
 - force, longitudinal, 545
 - force, relativistic, 120, 707, 783
 - hole boring. *See* hole boring
 - injection, 639
 - ion kick, 581
 - potential, 76
 - pressure, 617, 695, 702, 723, 726, 747, 765, 781
 - quiver velocity, 75, 504, 507
 - scattering, 110
 - shift of resonance. *See* Freeman resonance
 - steepening, 686, 694, 709, 713, 720, 724
 - term in Hamiltonian, 168, 250
 - wakefield excitation. *See* wakefield generation
- positron production, 8, 746
- potassium dihydrogen phosphate, 25, 46, 68
- Poynting theorem, 453
- PPT/ADK formula. *See also* ionization, tunneling
- prepulse, 49, 57, 61, 662, 668, 671, 732
- pressure
 - ablation, 693
 - electron, 395, 396, 418, 419, 463, 465, 468
 - gas backing, 392
 - light. *See* pressure, ponderomotive, 696, 701
 - ponderomotive. *See* ponderomotive, pressure, 697, 701, 726, 765
 - radiation, 765
- profile steepening, 727
- propagation operator, 164, 168, 238
- proper time, 80, 95, 103
- proton acceleration. *See* acceleration, ion
- pulse compressor, 35, 50
- pulse stretcher, 14, 38
- pulse temporal modulation
 - radial beam, 607
 - stimulated Raman, 599, 604
- pump depletion length
 - wakefield generation, 619
- Q-switch, 7, 19, 26
- QSA. *See* quasi-static approximation
- quantum interference
 - in ionization of diatomic molecules, 266
- quantum interferences
 - in the strong field approximation, 179
- quasi-classical model, 5
- quasi-classical three-step model, 4, 324
- quasi-energy. *See* Floquet, quasienergies

- quasi-neutrality, 422, 546, 581, 673, 674, 738, 755, 760
- quasi-static approximation, 547, 611, 615, 621, 629
 - 3D, 557, 564, 575
- quasi-stationary
 - potential, 255
 - wavefunction, 252
- quiver
 - amplitude, 75
 - energy, 2
 - velocity, 75
- Rabi frequency, multiphoton, 163
- Rabi oscillations, multiphoton generalization, 162
- radial beam envelope model, 512, 526
- radial beam modulation, 607
- radiation pressure acceleration. *See* acceleration, radiation pressure
- radiation reaction
 - free electron, 109
- Raman forward scattering, 599
- Raman scattering
 - forward, 7, 599
 - stimulated, 591
 - stimulated, backscatter, 591
 - stimulated, in density gradient, 730
 - stimulated, relativistic, 600
 - stimulated, threshold in density gradient, 732
- rarefaction wave, 671
- Rayleigh range, 88, 111, 126, 321, 353, 355, 357
- Rayleigh–Taylor instability, 707, 768
- recollision
 - atomic field ionization, 207
 - dynamics in high-harmonic generation, 324
 - dynamics in ionization, 207
 - in cluster, 457
 - ion momentum distribution, 215
 - relativistic suppression, 258
- recombination, 772
 - three-body, 417
- refraction
 - at a plasma surface, 681, 682
 - during super-continuum generation, 535
 - in filamentation, 528
 - plasma induced, 512, 514, 515, 538, 585
 - plasma, clamped maximum intensity, 521
- refractive index
 - complex, plasma, 503
 - nonlinear, 55, 512, 513, 526
 - nonlinear in air, 524, 528
 - nonlinear, phase-modulation, 535
 - plasma, 497
 - relativistic nonlinear, 536, 540
- regen. *See* regenerative amplifier
- regenerative amplifier, 25, 48, 50, 55, 58, 68
- relativistic induced transparency, 9
- relativistic intensity
 - definition, 79
- radiation emission, 92, 94
- relativistic-induced transparency, 780
 - ponderomotive pressure effect, 781
- REMPI. *See* multiphoton ionization, resonantly enhanced
- rescattering. *See also* recollision. *See* recollision, 225
 - cluster, 456
 - in above-threshold ionization. *See* above-threshold ionization, rescattering effects
 - in nonsequential double ionization, 204
- residual drift
 - angle, 89
 - distance, in finite pulse, 88
 - energy, 89
 - motion, 87
- residual drift energy, electron, 77
- resistivity
 - effect on return current, 740, 779
 - influence on magnetic field generation, 776
- resonance absorption, 710, 713
- resonances
 - in multiphoton ionization, 158
- retarded time, 91, 99–101
- return current, 737, 776, 778
- R*-frame, 94
- RIT. *See* relativistic-induced transparency
- rotating wave approximation, 300
- rotational constant, molecular, 284
- rotational partition function, 287
- rotational pumping, 291
- rotational revival, 290
- rotational state, 286
- RPA. *See* acceleration, radiation pressure
- saddle point
 - approximation, 176, 180
 - approximation, in high-harmonic generation, 333
 - method, 176
- SAE. *See* single active electron approximation
- saturable absorber, 30, 31, 68
- saturation intensity, 217, 220, 326, 361, 373, 386
 - barrier suppression ionization, 217
 - knee structure, 222
 - multiphoton ionization, 157, 180
- Schrödinger equation, 136, 144, 164, 169, 250, 294
 - length form, 187
- Schwinger field, 134
- selection rules
 - atomic high-harmonic generation, 321
 - solid target high-harmonic generation, 753
- self-channeling. *See also* filamentation. *See also* filamentation
- self-focusing, 13, 514
 - critical power, 526, 540, 567, 632
 - in air during filamentation, 524
 - in laser amplifiers, 55, 64
 - Kerr-lens mode-locking, 30
 - refractive reduction in plasma, 557

- relativistic, 7, 538, 567, 575
- self-focal length, 529
- self-induced opacity, 781
- self-induced transparency. *See* relativistic-induced transparency
- self-modulated wakefield generation, 613
- self-modulation
 - radial beam, 567
- self-phase modulation, 7, 385
 - fiber, 34
 - laser amplifier, 41, 55
 - plasma wave, 587
 - relativistic, 586
- self-similar
 - density profile, 468, 469, 671
 - expansion, 464
 - heat wave, 665
 - solution, 468, 664, 666, 671, 673, 758, 761
 - solution, expanding hot electron, 742
 - temperature profile, 664
 - variable, 667
- self-trapping
 - in wakefields, 637
- semiconductor saturable absorber mirror (SESAM), 30
- separatrix, 636
- SFA. *See* strong field approximation
- shake-off double ionization, 206
- sheath inverse bremsstrahlung, 729
- Siegert boundary conditions, 299
- single active electron approximation, 141, 204, 251
- skin depth
 - collisional, 734
 - collisionless, 700, 726, 782
- skin depth, collisionless, 663, 678
- slowly varying amplitude approximation, 87, 112, 513
- Snell's law, 690, 692
- sound speed
 - adiabatic, 467
 - hot electron, 761
 - hydrodynamic expansion, 669, 697
 - isothermal, 470, 662, 670, 671, 754
 - two-temperature, 673
- SP-OPCPA. *See* optical parametric chirped pulse amplification, picosecond
- space-charge, 423, 430, 464, 709, 714, 716, 726, 740, 757, 778, 779
 - amendment, 718
 - confinement, 741
 - force, 403
 - potential, 431
 - separation, 726
- spatial filter, 51, 56
- specific heat, 663
 - ideal gas, 663
 - ionizing plasma, 663
- spectral shaping, 19
- SRS. *See* Raman scattering, stimulated stabilization
- stabilization
 - dynamic, 249
 - ionization, 248
 - quasistationary, 249
- standing wave, 680, 686, 695, 698
- Stark shift
 - AC, 159, 163, 249
 - effect on resonant enhanced ionization, 224, 231
- steepest descent, method. *See* saddle point, method
- stimulated Brillouin scattering, 576, 590
- stimulated Raman scattering. *See* Raman scattering, stimulated
- stochastic heating, 423, 455
- stochastic scattering, 452
- Strehl ratio, 63
- stretcher. *See* pulse stretcher
- strong coupling in the continuum, 164
- strong field approximation, 3, 6, 166, 167, 171
 - above-threshold ionization prediction, 223
 - Coulomb correction, 194
 - diatomic molecule, 264
 - high-harmonic generation, 330
 - ionization rate, 177
 - limit of many photons, 175
 - weak field limit, 175
 - with complex atoms, 196
- strong field physics
 - definition, 1
- sudden approximation, 504
- supercontinuum generation, 534
- suprathermal electrons, 756, 774
- synchrotron radiation, 651
- target normal sheath acceleration. *See* acceleration, target normal sheath
- thermal velocity, 449, 504, 507, 508
- thermal wave, 662
- Thomson scattering, 110
 - linear, 91, 97, 128
 - nonlinear relativistic, 92
- three step model, quasi-classical, 324, 344, 363
 - quantum correspondence, 332, 335, 337
- THz radiation generation
 - plasma filament, 534
 - solid target, 784
- Ti:sapphire, 15, 16
- time-bandwidth product, 43
- TNSA. *See* acceleration, target normal sheath
- trajectory, electron, 317, 345
 - long, 325, 364, 370, 384
 - short, 325, 370, 380, 385
- transformation
 - wavefunction, 145
- trapping, electron, 635
- truncated summation method, 154, 157, 242, 246
- tunnel ionization. *See* ionization, tunneling
- tunneling time, 184

856

Index

- turning point, in a plasma density gradient, 681, 683, 705, 734
- two-photon absorption, 3
- two-plasmon decay, 732
- unitary transform, 250
- vacuum heating, 713
- valley of death, 257
- vector potential, 74, 77, 547, 592, 606
 - at sharp interface, 725
 - Coulomb gauge, 72
 - electron momentum, 121
 - gauge condition, 558
 - in electron Lagrangian, 72
 - normalized, 79, 88, 540, 624, 715
 - normalized, in ponderomotive force, 122
 - relation to fields, 72
 - time-averaged, 554
- velocity distribution, 508, 744
 - ion, 754
- velocity distribution, Maxwellian, 417, 470
- vibrational
 - excitation, 267
 - levels, 268
- Volkov state, 138, 168, 172, 330
 - Coulomb correction, 194
 - in rescattering, 238
- vorticity, plasma, 560
- wake potential, 561, 564, 629
- wakefield
 - generation, resonant excitation, 622
- wakefield acceleration. *See* acceleration, wakefield
- wakefield generation. *See also* acceleration, wakefield
 - multipulse, 626
 - self-modulated, 613, 631
- wave equation, 558, 681
 - electric field, 676, 683
 - Helmholz equation, 677
 - ion density perturbation, 583
 - magnetic field, 676, 683
 - paraxial, 111, 513
 - vector potential, 548, 549, 553, 592, 600, 723
- wavebreaking, 613, 619, 621, 624, 635
 - radial, 622
- wavefront curvature, plasma, 621
- wavefunction
 - plane-wave, 138, 151, 172, 239, 255
- wavelength shift, plasma, 621
- wavepacket
 - barrier penetration, 183
 - electron, 326
 - in the continuum, 335, 338, 339
 - nuclear in bond softening, 305
 - of rotational states, 290
 - periodicity in above-threshold ionization, 235, 244
 - recollision, 211, 214
 - recombining in *high-harmonic* generation, 326
 - spreading, 211, 239, 259, 279, 327, 341, 344, 345
 - tunneling, 185, 329
- Weibel instability, 776, 779
- white light emission, 535
- Wigner rotation operator, 269
- Wigner–Seitz radius, 404, 410, 411
- WKB
 - continuum states, 228
- WKB approximation, 171, 185, 188, 194, 228, 276, 648, 678, 683
- X-ray production, 660, 771
 - betatron, 643
 - cluster, 457, 490
 - hard, 774
 - inverse Compton, 129
 - K-alpha, 772
 - soft, 317, 747
 - thermal, 771
- XPW. *See* crossed-polarized wave generation
- XUV radiation, 317
- Yb-based laser materials, 21