

Index

A

- Absorption lines, 64, 65, 67, 317, 320–322, 331
- Absorption spectroscopy, time resolved, 300, 307, 313, 405
- ac Stark shift, 284, 289
- Adiabatic pulse compression, 211
- Air fill fraction, 222
- All-normal dispersion (AND) fibers, 92, 247–276, 368–376, 386
- Amplification length, 163–164
- Anomalous dispersion, 19, 101, 102, 107, 108, 112, 113, 116–120, 124–125, 130–131, 202, 204–205, 232, 247–251, 254, 267, 276, 375, 376, 379, 386, 387, 389, 391
- Anomalous dispersion regime, 102, 107, 112, 113, 116, 130, 202, 267, 369
- Antiferromagnetic crystals, 58–62
- Anti-stokes broadening, 10, 19, 22, 25–26, 28, 179
- Arsenic selenide nanowires, 231
- Arsenic trisulphide nanospike, 231
- Atmospheric remote sensing, 405
- Attosecond pulse, 273, 337–338, 341–351, 356–360, 364, 367, 413
- Attoseconds, 272, 273, 337–367, 411–413

B

- Biophotonics imaging, 247, 254, 256, 274–276
- Blue shift, 38, 82, 117, 119–121, 123, 126, 148, 149, 155, 156, 160, 216, 217, 228, 258, 328, 409

C

- Carrier envelope phase (CEP), 256, 273
- Cascaded stimulated Raman scattering, 201
- CEP. *See* Carrier envelope phase (CEP)
- CG pulses. *See* Chirped Gaussian (CG) pulses
- Chalcogenide fiber, 231, 270
- Chalcogenide Photonic crystal fiber, 231
- Charge transfer, 414
- Chemistry, 271–272, 405, 408–409, 416
- Chirp coefficient, 39
 - linear, 40
- Chirped Gaussian (CG) pulses, 107–110, 112, 113
- Chirp “linearization,” 273
- Chirps
 - impressed, 283
 - initial, 82, 111
 - linear, 39, 40, 81, 115, 131, 273
 - nonlinearity-induced, 379
 - pump, 167, 168
 - Stokes, 166–167
- Chlorine dioxide, 301–302, 331
- Clocks, 385, 405–406, 411–413, 419
- Coherence, 128, 130, 210, 211, 226, 227, 248, 254–257, 260, 264, 267, 270, 274–276, 372, 379, 382, 385, 388, 390–392, 407, 413, 414
 - length, 257
 - of supercontinuum, 128, 205, 206, 408
- Coherent anti-Stokes Raman scattering (CARS), 275, 299, 405, 413–415, 419
- Coherent control, 274, 275

- Colliding-pulse mode-locked (CPM) laser, 283, 303, 314
 - Coloured solitons, 207, 212
 - Comb frequency, 232, 256, 381, 382, 384–385, 411–413, 419
 - Complex light modes, 407–411, 419
 - Compression factor, 204
 - Compression ratio, 207, 272, 273
 - Compressors
 - double-pass fiber-grating pulse, 51, 144, 164, 204
 - Computational switches, optical, 405
 - Conical emission, 282, 295–297
 - Continuous wave (CW)
 - laser beam, 12, 127
 - Continuum generation. *See* Supercontinuum generation
 - Copropagating pulses
 - coupled nonlinear equations of, 136–140
 - induced-frequency shift of, 116, 119, 144, 150, 154–159
 - Coronagraph, 408, 410
 - Coupled nonlinear equations of copropagating pulses, 136–140
 - Cross correlation frequency resolved optical gating, 217
 - Cross-phase modulation (XPM). *See also* Induced-phase modulation (IPM)
 - applications for ultrashort pulse technology, 413
 - harmonic cross-modulation, 176–180
 - induced focusing by, 184–187, 192
 - modulation instability induced by, 172, 173
 - optical wave breaking due to, 116, 147, 148, 150
 - pump-probe experiments, 146, 150, 155
 - with second harmonic generation, 135, 179
 - spectral broadening induced by, 136, 140–146, 149, 159–160
 - stimulated four-photon mixing and, 136, 194
 - with stimulated Raman scattering, 34, 162–168, 173
 - theory of, 136–150, 159, 162–168, 194
 - CW pumped supercontinuum, 210, 223–228
- D**
- DABCO vapor
 - internal conversion rates in, 301, 313–317
 - Defocusing medium, 27
 - Degradation of coherence, 391
 - Degree of coherence, 130, 391
 - Delayed Raman response, 212
 - Diffraction ring pattern, 13
 - Dispersion
 - anomalous, 91, 101, 102, 107, 108, 112, 113, 116–120, 124, 125, 130, 131, 202, 204–205, 232, 247–250, 253–254, 267–268, 276, 375, 376, 379, 386, 387, 389, 391
 - decreasing characteristics, 211, 221, 381, 382
 - group velocity (*see* Group velocity dispersion)
 - length, 84, 106, 109, 113, 114, 121, 122, 146, 163
 - normal, 19, 81, 82, 92, 107, 108, 114–116, 128–131, 141, 146, 147, 187–189, 191, 194, 204, 207, 209, 212, 215–216, 225, 232, 248, 249, 252–254, 256, 261–264, 267–271, 276, 376, 381–383, 386–387, 390
 - Dispersion-dominant regime, 105–109
 - Dispersionless medium
 - analytical solution for SPM in, 162
 - Dispersive effect, 3, 101–102, 141, 259–260
 - Dispersive nonlinear regime, 112–114
 - Dispersive wave, 113, 117–121, 123, 126, 127, 131, 204, 207, 216–221, 223, 225, 226, 228, 232–233, 251–254, 266–267
 - Dispersive wave trapping, 217, 218
 - Distributed feedback dye laser (DFDL), 302
 - Distributed Raman amplifier, 211
 - Doppler shift, 409
- E**
- Electric field, 35, 36, 39, 43, 52, 57, 82, 84, 94, 96, 102, 107, 137, 162, 190, 213, 282, 339, 359, 371, 390–391
 - envelope, 35, 36, 39, 52, 82
 - Electric vector, 57
 - Electronic resonances in crystals, supercontinuum near, 6
 - Electrostriction, 7, 8, 42, 43, 54, 55
 - Envelope model, 213
 - Event horizon, 406, 417–419
 - Excimer amplifier system, 302–305
 - Excitation spectroscopy, time-resolved, 405
 - Expansion parameter, 15, 19
 - Extreme temporal narrowing, 204

F

Fast Fourier transform (FFT) method, 140, 329
 Femtosecond light pulses, 2, 40–41
 Femtosecond pulse compression, 184, 207
 Femtosecond Raman pulses, 174–176
 Few-cycle pulses, 254, 270–274, 343, 379
 FFT method. *See* Fast Fourier transform (FFT) method
 Fiber based pulse sources, 302
 Fiber *entries*, 2, 42, 101, 136, 247, 287, 302, 352, 405. *See also* Optical fiber *entries*
 Fiber-grating compressor parameters, 204
 Fiber integrated supercontinuum source, 210, 219
 Fiber loss, 103, 105, 109, 110, 116
 Fiber Raman amplification soliton laser (FRASL), 168–171
 Filaments, 41–45, 62–65, 68, 77, 80, 174, 200, 248, 373, 374, 418
 Filter transform, 351
 First supercontinuum generation in fiber, 120–131, 201, 208–210, 214, 216, 228
 Focusing, induced. *See* Induced focusing
 Focusing medium, 21, 22
 Four-photon parametric generation (FPPG), 33, 68, 75, 151, 155
 Four wave mixing (FWM), 19, 102, 116, 121, 126–128, 131, 146, 160, 200–202, 206, 208, 210, 220, 222, 225, 248, 258–259, 372, 375, 391, 406, 418
 FPPG. *See* Four-photon parametric generation (FPPG)
 FRASL. *See* Fiber Raman amplification soliton laser (FRASL)
 Frequency combs, 216, 232, 256, 337, 381, 382, 384–385, 411–413, 419
 Frequency modulation, 9–10
 Frequency shift
 maximum, 39, 78, 159, 206
 f to $2f$, 384
 FWM. *See* Four wave mixing (FWM)

G

Gaseous continua
 spatial characteristics of, 294–296
 spectral characteristics of, 291–194
 Gases
 saturation of nonlinear response in, 289–290

self-focusing in, 1–3, 12–14, 20–30, 41, 43, 55, 59, 80–82, 93, 146, 174, 185, 200, 202, 248, 281–297, 306
 Gas-filled kagomé photonic crystal fiber, 232
 Gas filled photonic crystal fiber, 231–233
 Gaussian pulses
 chirped (CG), 107, 108, 112
 General NLSE, 212, 213
 Generation of supercontinuum, 42–51, 62–67, 212, 214, 406
 Germanium doped fiber, 226
 Glass optical fibers, supercontinuum in, 51
 Graded index profile, 186
 Group delay dispersion (GDD), 356–357
 Group velocity, 35, 51, 52, 54, 74–81, 93–96, 102, 119, 136–141, 144, 146, 148, 156, 158, 159, 162, 163, 169, 172, 174, 179, 190, 192, 203, 207, 216, 220–222, 247, 253, 258, 259, 307, 343, 374
 Group velocity dispersion (GVD)
 effects of, 81
 negative, 141
 nonlinear wave equation with, 93–96
 positive, 141, 169
 Group velocity mismatching, 220
 Group velocity mismatch, 139–141, 148, 156, 192
 GVD. *See* Group velocity dispersion (GVD)

H

Hawking radiation, 417–419
 High average power, 209, 219, 220, 225, 383
 High-order soliton, 116–119, 212, 233, 251, 252, 386
 High spectral power density, 219
 Holes, 124, 221, 225, 262, 265, 269, 352, 353, 365, 375, 417–418
 Holey fiber, 92, 127
 Horn-shaped pulse, 26–28
 Hyperpolarizabilities, 57, 291–292, 294, 296

I

Imaging, 42, 127, 130, 131, 228, 247, 254, 256, 271, 274–276, 405–406, 408–410, 413, 414, 416–417, 419
 Impulsive Stimulated Raman (ISR), 413, 415
 Index of refraction. *See* Refractive indexes
 Induced focusing
 by cross-phase modulation, 184–187

- Induced-frequency shift of copropagating pulses, 154–159
- Induced modulational instability, 202–206, 208, 209, 213, 220, 222, 223, 225, 227, 229, 232, 388–389, 391
- Induced nonlinear effects, 3, 35, 101, 105, 106, 112, 120, 130, 150, 154–155, 187, 250, 258
- Induced-phase modulation (IPM), 34, 39, 92, 136–137, 151, 154. *See also* Cross-phase modulation (XPM) based optical computational switches, 405 of generated second harmonic pulse, 136, 154, 176–179 Raman amplification and, 168–172 spectral broadening enhancement by, 136, 140–146, 159–161
- Induced polarization, 4, 135
- Induced pulse compression, 2, 41, 51, 101, 136, 140, 146, 150, 162, 184, 191–193, 203, 207, 211–212, 214–215, 232, 247, 252, 254, 271–274, 286, 287, 378–379, 405
- Induced ultrafast supercontinuum pulse (IUSP), 68, 152
- Infrared (IR) laser pulses, 3, 150, 154–159, 309, 311–313, 363
- Infrared supercontinuum generation, 230
- Infrared supercontinuum sources, 230–231
- Instantaneous Kerr, 212
- Integrated intensity, 61–62, 315–316
- Intensity fluctuations, 125, 227–228, 390
- Interference, 10–11, 33, 34, 38, 49, 86, 148, 179, 185, 204, 254, 258, 259, 274, 350, 351, 353, 361, 362, 407, 412
- Interference fringes, 254, 353
- Interference pattern of supercontinuum, 353
- Ionization, multiphoton, 281–286, 289–291, 297
- IPM. *See* Induced-phase modulation (IPM)
- ISR. *See* Impulsive Stimulated Raman (ISR)
- IUSP. *See* Induced ultrafast supercontinuum pulse (IUSP)
- J**
- Jitter, 210, 211, 256
- K**
- Kagomé fiber, 232
- Keldysh theory, 284, 285
- Kerr distance, 163
- Kerr gate, optical (OKG), 68, 191, 192
- Kerr liquids, 27
- Kerr medium optical, 418
- Kinetic spectroscopy promising directions for, 302, 333–334
- L**
- Laser beams. *See* Lasers
- Laser heating, 7
- Laser-induced fluorescence (LIF), 299, 301
- Laser pulses femtosecond, 2, 24 infrared, 3 picosecond, 2, 39, 56, 59
- Lattice defects, transient, 262
- Launch around dispersion minimum, 207
- Librational frequencies, 6
- LIF. *See* Laser-induced fluorescence (LIF)
- Light pulses. *See* Laser pulses
- Linear and angular momentum, 407
- Linear chirp coefficient, 40
- “Linearization,” chirp, 40
- Low-intensity pulses, 188
- Low threshold supercontinuum, 231
- M**
- Master oscillator power fiber amplifier, 214, 219
- Maxwell’s equations, 83, 103. *See also* Wave equation
- Metrology, 128, 215, 247, 256, 372, 384, 389, 405, 407, 412, 419
- Microscopy, 86, 88, 181, 185, 188, 263, 266, 275, 405–406, 408–409, 413–417
- Microstructure fibers, 119, 120, 124, 230, 250, 262, 270, 272, 376, 379, 384, 391, 406
- Mid-infrared spectral region, 269–271
- Modal dispersion, 212
- Modelling broadband propagation, 212–214
- Modelling CW pumped supercontinua, 227–228
- Modelling femtosecond pumped supercontinua, 217–218
- Modelling picosecond pumped supercontinua, 223
- Mode-locked, 34, 39–41, 50, 86, 151, 155, 159, 172, 177, 185, 188, 200, 202, 203, 205, 208, 210, 214, 216, 219, 228, 230, 283, 302, 303, 381, 384, 385, 390, 412

- Mode-locked lasers, 34, 40, 41, 185, 381, 390
 Mode-locked Ti:sapphire laser, 214, 216
- Modulation
 cross-phase (*see* Cross-phase modulation)
 frequency, 38, 39, 49, 59, 67, 205, 291, 380, 409
 induced-phase (*see* Induced-phase modulation)
 phase, 22
 self-phase (*see* Self-phase modulation)
- Modulation instability (MI), 202–206, 208, 209, 211, 213, 215, 220, 222–225, 227–229, 232, 256, 257, 261, 376, 379, 380, 387–391
- Molecular redistribution, 7, 8, 36, 42, 55
- Multiphoton ionization, 281–286, 289, 297
- Multiple information channels, 210
- Multiple scale method, 136
- Mutual coherence function, 256, 257
- Mutual incoherent, 248–249, 256, 275
- N**
- Near infrared imaging, 416–417
- Negative frequencies, 141, 213
- Noise, 19, 125, 169, 172, 176, 190, 204, 206, 208, 210, 211, 213, 215, 222, 223, 226, 227, 247–249, 254–257, 271, 272, 300, 349, 350, 374, 377, 378, 380, 381, 384–388, 390–391, 415
 amplification, 248, 256, 380, 386, 387
 seeding, 222
- Nonlinear coefficient, 52
- Nonlinear effects, induced, 258
- Nonlinearity-dominant regime, 109–112
- Nonlinearity-induced chirps, 187
- Nonlinear multi-mode effects, 232
- Nonlinear pulse compression, 247, 271–274
- Nonlinear pulse propagation, 250
- Nonlinear refractive index, 35, 39, 54, 57, 62, 68, 74, 80, 85, 94, 138, 184–186, 192
- Nonlinear response function, 103
- Nonlinear response in gases, saturation of, 289–290
- Nonlinear Schrödinger equation (NSE), 249
- Nonlinear superposition, 204
- Nonlinear wave equation
 with group velocity dispersion, 35, 51, 74–76, 78, 80, 81, 96, 102, 162, 169, 172, 174, 190, 221
- Normal dispersion regime pump, 81, 82, 92, 107, 114, 128, 129, 146, 147, 187–189, 194, 209, 216, 225, 248, 249, 256, 261–264, 267, 374, 376, 386, 390
- NSE. *See* Nonlinear Schrödinger equation (NSE)
- Numerical modeling, 127, 249–250
- O**
- Octave spanning, 130, 249, 252, 254, 260, 272, 273, 379, 385, 386
- OKG. *See* Kerr gate, optical (OKG)
- Optical amplification of probe pulses, 160
- Optical Clock, 385, 405, 411–413, 419
- Optical coherence tomography (OCT), 210, 248, 274, 372, 413, 416
- Optical communication, 150, 371, 406, 408, 411, 412, 419
- Optical computational switches, 405
- Optical density, induced transient, 63
- Optical fiber *entries*. *See also* Fiber *entries*
- Optical fiber measurements, 405
- Optical-field-induced refractive indexes, 5
- Optical grating. *See* Grating pair
- Optical Kerr effect, 35, 72, 73, 200
- Optical Kerr gate (OKG), 68, 72, 191, 192
- Optical Kerr medium, 418
- Optical multichannel analyzer (OMA), 68, 156, 174, 181, 188, 294, 307, 314, 315, 333
- Optical nonlinearities, kinetics of, 405
- Optical pulse compression
 in single-mode fibers, 130
- Optical pulse *entries*. *See also* Pulse *entries*
 self-steepening of, 11, 18, 20
- Optical solitons, 101, 116, 131, 202–204, 208, 232, 377
- Optical Vortex, 407, 409–411
- Optical wave-breaking
 due to cross-phase modulation, 146–150
- Orbital Angular Momentum, 407
- P**
- Particle trapping, 408, 410, 419
- Peak intensity, 49, 59, 64, 86, 182–184, 274, 286, 296, 340–341, 344–347, 356, 357, 361
- Penalty free transmission, 211
- Phase difference, 350
- Phase factor, time-dependent, 54

- Phase increment, 12, 21, 22, 26
- Phase modulation, 3, 9–11, 16, 19, 21, 22, 25, 27, 67, 154, 162, 164–166, 348, 349
- Phase shift, 9, 102, 109, 156, 158, 163, 167, 169
- Photo-darkening, 226
- Photodissociation, iodine, in solution, 299, 301, 308
- Photoexcitation, 300, 314
- Photonic bandgap, 384
- Photonic crystal fibers (PCF), 112, 120, 126–130, 214–217, 219–227, 229–233, 247–258, 262–265, 267–269, 272, 273, 275, 371, 375, 376, 386, 391
- Photoreaction of rhodopsin, 415
- Photorefractive, 7
- Photosynthesis process, 414
- Picosecond laser pulses, 2, 39, 56, 59
- Picosecond pulse pumped supercontinua, 219–222
- Picosecond Raman pulses, 162, 164, 172–174
- Plasma density changes, 283
- Plasma induced phase modulation, 233
- Polarization, induced, 4, 135
- Polarization-preserving fiber, 217
- Polarization vector, 137
- Power-length factor, 200
- Power spectrum, 10, 11, 23, 24, 28, 409
- Probe pulses, optical amplification of, 160
- Probe spectral distribution, 161
- Propagation equation, 102–104
- Propagation regimes, 102, 104–114
- Pulse amplitude, 18, 327
- Pulse comoving coordinate, 203
- Pulse-compression switch, 191–193
- Pulse compression techniques
 - optical (*see* Optical pulse compression)
- Pulsed quasi-monochromatic field, 4
- Pulse *entries*
 - copropagating (*see* Copropagating pulses)
 - Gaussian (*see* Gaussian pulses)
 - horn-shaped, 26–28
 - laser (*see* Laser pulses)
 - light (*see* Laser pulses)
 - low-intensity, 113, 188
 - optical (*see* Optical pulse *entries*)
 - probe, 135, 136, 139–152, 156, 159–161, 184, 191, 192, 194, 301, 307, 308, 316, 317, 320, 332, 415
 - pump, 73, 75, 77, 78, 92, 135, 136, 139, 141, 144, 146–150, 153, 154, 158–166, 169, 172, 174–176, 178, 179, 182, 184, 191–192, 202, 205, 206, 209, 215, 217, 219, 222, 232, 233, 247–250, 253, 256, 257, 259–261, 264, 267, 272, 273, 276, 301, 306–309, 316–318, 320, 321, 374, 376, 377, 388, 415
 - Raman (*see* Raman pulses)
 - steepening, 16
 - ultrashort (*see* Ultrashort pulse generation)
 - walk-off (*see* Walk-off *entries*)
- Pulse envelope, 33, 36, 38, 78, 84, 92, 94, 96, 102, 103, 138, 159, 203
- Pulse phase, 135, 140
- Pulse propagation, 16, 26, 27, 29, 61, 68, 101–131, 212–214
 - nonlinear, 250
- Pump chirps, 167, 168
- Pump incoherence, 227
- Pump in region of minimum dispersion, 208
- Pump loss distance, 164
- Pump-probe cross-phase modulation
 - experiments, 150–161
- Pump pulses, 73, 75, 77, 78, 92, 135, 136, 139, 141, 144, 146–150, 153, 154, 158–166, 169, 172, 174–176, 178, 179, 182, 184, 191–194, 202, 205, 206, 209, 215, 217, 219, 222, 232, 233, 247–251, 253, 256, 257, 259–261, 264, 267, 272–273, 276, 301, 306–309, 316–318, 320, 321, 374, 376, 377, 388, 415
- Q**
- Q-switched, 2, 124, 188, 189, 201, 202, 208
- Quadratic compressors, 379
- Quantum noise fluctuations, 213
- Quasi-monochromatic field, pulsed, 4
- Quasi-steady-state self-focusing, 20, 26
- R**
- Raman amplification, 168–172, 204, 211, 382, 389
- Raman frequency comb generation, 232
- Raman gain, 119, 163, 164, 168, 209, 210, 220, 225, 256
- Raman gain spectrum, 103, 104
- Raman process, walk-off and, 168
- Raman pulses
 - femtosecond, 174–176
 - picosecond, 162, 164, 172–174
- Raman transitions, 6
- Random femtosecond solitons, 220
- Rare-gas liquids and solids,
 - supercontinuum in, 56

- Rayleigh backscatter, 210
 Rayleigh wing spectrum, 8
 Refractive indexes
 graded, 186
 Kerr, 373
 nonlinear, 35, 39, 54, 57, 62, 138, 184,
 185, 200, 203, 373
 optical-field-induced, 4–8
 total, 36
 Relaxation time responses, 55
 Remote sensing, atmospheric, 423
 Resonant structure, 15, 31
 Rogue waves, 234
- S**
- Salt concentration dependence, 70
 Saturation
 of nonlinear response in gases, 29, 92, 103,
 150, 289–290
 Schrodinger equation, nonlinear. *See* Nonlinear
 Schrödinger equation (NSE)
 Second harmonic generation (SHG), 34, 41, 50,
 68, 88, 135, 136, 151, 154, 155, 159,
 176–179, 194, 222, 275, 303, 305,
 309, 345, 346, 384
 Second harmonic generation cross-phase
 modulation (SHG-XPM), 34, 180
 Second harmonic pulse, generated, IPM of,
 136, 154, 177–179
 Seeding of modulational instability, 206, 209,
 222, 256
 Self-coherence function, 206, 210, 211,
 226, 227, 248, 255, 257, 266,
 270, 274, 276, 385, 386,
 390–391, 407, 412, 413
 Self-focusing
 in dispersionless medium, 4
 distance, normalized, 2, 12, 20, 21, 27, 82
 in gases, 3, 20, 24–26, 29, 281–297
 longitudinal, 26, 262, 303, 380, 384,
 409, 410
 quasi-steady-state, 20–24, 26, 164
 self-phase modulation and, 1–30, 35, 36,
 49, 92, 102, 135, 139, 145, 146, 151,
 166–168, 176, 178, 186, 200, 202
 transient, self-phase modulation
 with, 26–28
 Self-phase modulation (SPM)
 analytical solution for, 36, 84, 138
 in bulk homogeneous material, 51, 80, 82,
 118, 120, 136, 199, 200, 373
 experimental arrangement for, 40–42, 86,
 88, 231
 higher-order effects on, 80–82, 93
 local generation and propagation of, 75–78
 measurement of, 3, 29, 42, 54, 68, 72, 73,
 79, 82, 92, 128, 151, 152, 172,
 174, 178, 189, 190, 194, 199,
 200, 202, 270, 274, 306, 313,
 384, 385
 more rigorous theory of, 6, 14–19
 in parabolic graded index medium, 144
 pulse duration reduction, 73, 78–80
 review of conventional theory, 65, 147,
 215–217, 248–257
 self-focusing and, 1–3, 12, 20–22, 29, 30,
 185, 200, 202, 248, 294–297, 306
 simple theory of, 3, 8–17, 20
 simplified model, 35–40
 spectral distribution predicted by, 51, 62,
 82, 136, 151, 154, 161, 177
 spectral maximum shift, 10, 17, 21, 48, 49,
 284, 286
 temporal and spatial, 135, 136, 191,
 192, 194
 temporal behavior of, 73–80
 temporal distribution of, 39, 73–76,
 79–80, 152
 with transient self-focusing, 26–28
 in unbounded media, 287
 Self-Raman interaction, 206, 207, 209,
 215, 222
 Self-steepening
 early, 16, 20, 25, 124
 effect, 2, 14, 16–18, 25, 29, 82, 217
 induced, 233
 of optical pulses, 212
 pulse in dispersionless medium, 18
 Self-terminating process, 206
 Semiconductors
 coherent transients in, 320
 supercontinuum in, 48–49
 supercontinuum spectroscopy of, 48–49,
 230, 301, 320
 SF6 photonic crystal fiber, 230
 SFPM. *See* Stimulated four-photon mixing
 (SFPM)
 SHG. *See* Second harmonic generation (SHG)
 Shock-forming distance, 212
 Shortest pulse duration, 252, 273
 Short tapered fibers, 212, 268
 Shot-to shot noise, 223
 Silicon-intensified target (SIT) camera, 42
 Single-mode fibers, pulse compression in, 116,
 128, 130, 147, 302, 406
 SIT camera. *See* Silicon-intensified target (SIT)
 camera

- Slowly varying amplitude (SVA), 9, 103, 136, 137
- Slowly varying envelope approximation (SVEA), 137, 328
- Soft glass fibers, 269, 270, 276
- Soliton-dispersive wave trapping, 217–221, 223, 225, 226
- Solitonlike solutions, 205
- Soliton-plasma interaction, 232
- Soliton Raman, 169, 202, 208–210, 225, 227, 228
- Solitons
 - breathing, 203
 - collisions, 126, 209, 222, 225, 379
 - compression, 205, 206, 211, 212, 374
 - dark, 418
 - fission, 118, 121–124, 128, 129, 207, 212, 217, 218, 227, 232, 251–252, 267, 268, 386–388
 - fundamental, 113, 114, 116–119, 125, 126, 131, 204, 207, 219, 225, 251, 254, 386
 - gas, 228
 - laser, 116, 168–172, 203
 - from noise bursts, 204
 - pulse compression, 211, 252
 - pulse instabilities, 206–207
 - pulse restoration, 3, 14, 19, 29
 - quasi-solitons, 124
 - self-frequency shift, 119, 136, 207, 209, 217, 221, 232
 - solutions, 203
- Soliton-soliton interaction, 203
- Solute-solvent, 72
- Spatial coherence, 390, 407, 408, 412, 413
- Spectral broadening
 - asymmetric, 81, 82, 172
 - enhancement
 - by induced-phase modulation, 92, 137, 151, 154
 - more rigorous theory of, 3, 7, 11, 14–19
 - self-induced, 1, 4, 6, 33
 - simple theory of, 8–17
 - of ultrashort pulses, 15, 20, 24–26, 101–131, 135–195
 - XPM-induced, 140, 149, 159–161
- Spectral coherence, 128
- Spectral distribution
 - probe, 136, 150, 152, 154, 161
- Spectral extents, 51, 81, 82, 220, 225, 226, 307
- Spectral intensity, 25, 59, 85, 106, 140, 152, 261, 264
- Spectral interference, 25, 59, 85, 106, 140, 152, 254, 257, 258, 261, 264, 384
- Spectral-temporal breathing, 204
- Spectroscopy
 - coherent anti-Stokes Raman scattering, 275, 299, 405
 - kinetic (*see* Kinetic spectroscopy)
 - supercontinuum, of semiconductors, 34, 41, 48–49, 230, 319, 320
 - time-resolved absorption, 307, 318, 405
 - time-resolved excitation, 405
 - ultrafast, 256
- Split step Fourier method, 114, 213
- SRS. *See* Stimulated Raman scattering (SRS)
- SRS-XPM. *See* Stimulated Raman scattering cross-phase modulation (SRS-XPM)
- Stark shift, ac, 289, 320
- STED microscopy. *See* Stimulated emission depletion (STED) microscopy
- Stimulated Brillouin scattering, 200, 210
- Stimulated emission depletion (STED) microscopy, 408–409, 413, 416, 419
- Stimulated four-photon mixing (SFPM) cross-phase modulation and, 135–195
- Stimulated Raman scattering (SRS)
 - cross-phase modulation with, 33, 68, 102, 135–195
 - pulse compression and, 2, 41, 51, 101, 140, 146–150, 162, 164, 184, 191–193, 203, 204, 211, 212, 215, 232, 252, 254, 271–274, 287, 302, 378–379, 405
- Stimulated Raman scattering cross-phase modulation (SRS-XPM), 33–34
- Stokes and anti-Stokes shifts, maximum, 17, 18, 44, 47, 49, 62–65, 77, 78, 178, 181, 206
- Stokes-anti-Stokes asymmetry, 11, 14, 16, 17, 28
- Stokes broadening, 10, 17, 19, 23, 25, 26, 28, 179
- Stokes chirps, 166, 167
- Stokes wave, 74, 79, 183, 311, 414
- Streak camera, 54, 74, 79, 87, 152, 172, 177, 180, 307, 347, 352
- Sub-micron diameter fibers, 216, 231, 263, 265, 410
- Superbroadening. *See* Spectral broadening
- Supercontinuum
 - coherence, 128
 - gaseous (*see* Gaseous continua)
 - generation, 3, 33–96, 101, 102, 120–128, 154, 174, 199–203, 205, 216, 217, 226, 230, 231, 305–309
 - interference pattern of, 353, 362
 - laser, 194, 408, 414

- mid-infrared wavelengths, 231
 - present and future applications of, 194, 258, 379, 389, 405
 - quantum mechanical treatment of, 5, 213, 351
 - spectroscopy of semiconductors, 34, 41, 48–49, 230, 301, 320
 - stability, 211, 215, 216, 267, 274, 308
 - sweep rate, 327
 - in telecommunications, 101, 210–212, 216, 263, 373, 381, 385, 391
 - temporal characteristics, 150, 177, 227, 253–254, 338, 347–351
 - thermal focusing effects on, 270, 271
 - UV wavelengths, 3, 34, 120, 249, 266, 268, 305–309, 318, 337–367, 413
 - Supercontinuum generation
 - in antiferromagnetic crystals, 58–62
 - in calcite, 44, 47, 93
 - in carbon tetrachloride, 50
 - in condensed matter, 33–96, 306
 - enhancement of, in water, 68–73, 93, 151, 153, 194, 221
 - experimental, 214
 - in gases, 3, 34, 54–62, 232, 306–310
 - in glasses, 34, 39, 43–45
 - infrared, 34, 47, 48, 93, 120, 128, 174, 209, 226, 230–232, 300, 301, 413
 - in liquids, 34, 42–44, 50–51, 54–59, 66
 - near electronic resonances in crystalsnear electronic resonances in crystals, 6, 40, 140, 193
 - in optical fibers, 51–54
 - in phosphoric acid, 50–51
 - in polyphosphoric acid, 51
 - in potassium bromide, 47, 93
 - in quartz, 42, 45, 46, 93, 177, 179, 375, 376
 - in rare-gas liquids and solids, 54–58
 - in semiconductors, 48–49, 230
 - in sodium chloride, 46, 68, 93
 - in solids, 34, 42–50, 54–58, 375, 405
 - threshold power for, 56, 291
 - ultraviolet, 3, 34, 120, 249, 266, 305–309, 337–367, 413
 - in water, 50, 51, 68–73, 201, 216, 225, 418
 - Susceptibility, 4, 8, 34, 35, 59, 103, 137, 180, 281, 282, 285, 286, 289, 290
 - Suspended-core fibers (SCF), 262, 265–267
 - SVA. *See* Slowly varying amplitude (SVA)
 - SVEA. *See* Slowly varying envelope approximation (SVEA)
 - Sweep rate, supercontinuum, 327
 - Switches, optical computational, 140, 150, 405
- T**
- Tapered fiber, 92, 211, 213, 221, 266
 - Tapered photonic crystal fiber, 127, 216, 220, 267
 - TDM. *See* Time-division multiplexing (TDM)
 - Tellurite fiber, 230, 382
 - Temperature gradient, 7, 59–62
 - Temporal coherence, 128, 255, 407, 416
 - Temporal tuning, 94
 - Terabits/s, 385
 - Thallium chloride molecules, 307
 - Thermal focusing effects on supercontinuum, 270, 271
 - THG. *See* Third harmonic generation (THG)
 - Third harmonic generation (THG), 49, 200, 213, 275
 - Three-dimensional imaging, 27, 30, 416
 - Threshold gain, 47, 56, 146, 172–175, 181, 188–190, 200, 231, 232, 265, 268, 284, 287, 290–297, 344, 382
 - Threshold power for continuum generation, 56, 291
 - Time-dependent phase factor, 19, 28, 29, 36, 37, 54, 82, 107, 110, 144, 283, 326, 343
 - Time-division multiplexing (TDM), 383–384
 - Time-resolved absorption spectroscopy, 307, 318
 - Time-resolved excitation spectroscopy, 342
 - Time-resolved infrared spectral photography (TRISP)
 - application of, 309–313
 - Transform limited (TL) pulses, 168, 203, 205, 273, 283, 358, 359, 361
 - Transverse coherence, 1, 5, 7, 12, 20, 51, 91, 94, 137, 295, 303, 407, 413
 - TRISP. *See* Time-resolved infrared spectral photography (TRISP)
 - Tunable femtosecond pulses, 2, 207, 210
- U**
- U curve, 21, 22
 - Ultimate clocks, 381, 411, 412
 - Ultrafast applications, 68, 194, 248, 256, 271, 275, 276, 309
 - Ultrafast spectroscopic studies, 256
 - Ultrafast supercontinuum pulse (USP), 80, 81, 164, 398
 - Ultrashort pulse generation, 203, 209, 386
 - Ultrashort pulses, spectral superbroadening of, 3, 14–20, 24–26, 29
 - Ultrashort pulse technology, cross-phase modulation in, 15, 24–27, 29, 34, 101–131, 135–195, 203, 204, 207,

220, 252, 253, 259, 264, 275, 281,
284, 290, 297, 379, 380, 413
Ultraviolet (UV), 3, 34, 120, 249, 266, 305–309,
315, 317, 333, 337–367, 413
 spectral region, 266–268
 supercontinuum generation, 231–233,
 306–308, 317, 333, 334
 supercontinuum sources, 231–233
Uncertainty relation, 2, 9, 17, 284
Unidirectional pulse propagation equation, 213
USP. *See* Ultrafast supercontinuum pulse (USP)
UV. *See* Ultraviolet (UV)
UV-dispersive wave emission, 216, 268
UV-extended supercontinuum, 216, 268
UV-radiated fiber, 268

V

Vacuum uv generation, 232, 268
Visibility, 34, 50, 65, 127, 128, 164, 180, 191,
201, 208–210, 215–217, 219, 226,
228, 232, 259, 262–266, 271, 301,
306, 307, 309, 311, 314, 316, 365,
374, 375, 410

W

Walk-off *entries*
 distance, 63, 167

 Raman process and, 6, 164, 166, 174,
 206, 225
Water loss, 201, 225
Wave equation
 nonlinear (*see* Nonlinear wave equation)
Wavelength division multiplexing (WDM)
 systems, 210, 211, 379, 381–385,
 391, 411
WDM systems. *See* Wavelength division
 multiplexing (WDM) systems
White light, 92, 135, 276,
 384, 412
White light continuum, 92, 412

X

X-ray attosecond, 272, 273, 364, 413

Z

ZBLAN fiber, 230
ZBLAN Photonic crystal fiber, 231
ZDW. *See* Zero dispersion
 wavelength (ZDW)
Zero dispersion wavelength (ZDW), 108, 209,
 217, 218, 221, 222, 231,
 232, 247–249, 253, 262, 265,
 268, 276