

- α (alpha), I: 60
 a (ay), I: 55, 58, 60
 absolutely continuous measure, II: 375
 AC property, II: 381
 IV: 12
 absorbed flux, I: 55, 58
 absorbed radiant energy, III: 94
 absorption (of a finitely deep slab of water, A_γ)
 I: 70
 measurements, I: 103
 length, I: 110
 absorption function (for irradiance), V: 12, 97
 simple formula for in asymptotic light field,
 V: 255
 absorption time constant
 III: 82
 abstract spherical harmonic method, III: 143
 AC property, II: 381, IV: 32
 acceleration (for a fluid packet), VI: 48
 adaptation level (for visibility), I: 160
 addition theorem for spherical harmonics, III: 148, 153
 aerial stereo photography (for spectra), VI: 166
 air-water surface
 elementary hydrodynamics for, VI: 46
 Fourier series, integral representations, VI: 87, 101, 109
 working representation, VI: 115
 integral equation for instantaneous surface radiance, VI: 215, 234
 weighting functions, VI: 221
 time-averaged equation for surface radiance, VI: 223, 234
 synthesis of results, VI: 246
 albedo, II: 216
 albedo for single scattering (see *scattering-attenuation ratio*)
 algebra
 of reflectance and transmittance operators, II: 230
 normal, II: 243
 Banach, V: 244
 algebraic properties of R,T
 IV: 27
 invariant imbedding relation, IV: 35
 algebraic spherical harmonics, III: 141
 altitude (in a reference frame), II: 19
 Ambarzumian's principle, II: 228. IV: 34
 amplitude spectrum VI: 115,
 see *spectrum*
 analytic properties (invariant imbedding relation), IV: 68
 anemometer height, VI: 181
 angle, polar, azimuthal, II: 24
 apparent optical properties,
 I: 118
 defined, listed, I: 135,
 V: 106, 178, 181
 transport equations for,
 V: 271
 operational definitions reviewed, VI: 324
 apparent radiance, I: 60
 II: 362
 apparent radiance
 canonical representation,
 III: 16
 apparent-radiance equation,
 II: 361
 apparent wave period, height
 VI: 183
 astrophysical optics, defined,
 I: 1
 asymmetries of the Ψ -operator,
 IV: 179
 asymptotic form of light fields, V: 95
 criterion for asymptoticity,
 V: 254
 asymptotic properties (of R,T)
 IV: 33, IV: 104
 or radiance, IV: 127
 of polarized radiance,
 IV: 128
 asymptotic radiance hypothesis,
 I: 41, V: 212
 algebraic proof, IV: 127
 main mathematical proof
 (using canonic equations for K), V: 213-227
 integral equation for limit radiance distribution,
 V: 228, 237, 245
 theoretical and experimental example, V: 229, 230

- asymptotic radiance hypothesis
 --Cont'd.
simple proof (using exponentiality of $h(z)$), V: 230
 practical consequences, V: 238
 K characterization of hypothesis, V: 242
 critique of Whitney's "general law", V: 248
heuristic proof (using differential equation for K), V: 253
- atmospheric radiative transfer, gross features, I: 27
- attenuated radiant energy, III: 94
- attenuating functions
 depth dependence, V: 25
- attenuation functions (for irradiance), V: 11
 depth dependence, V: 25
 for radiance, V: 264
 for irradiance, V: 265
 for scalar irradiance, V: 270
 for reflectance, V: 149, 279
 for K-function, V: 275
 for other concepts, V: 281
- attenuation length, I: 90
 III: 99, 196
- attenuation time constant, III: 76
 scattering, III: 10
- autocorrelation, VI: 96
- back scattered flux, I: 55
- backward scattering functions, V: 11, 141
 experimental determination, VI: 335
- Banach algebra, II: 244
- Beam transmittance, I: 120
- Beam transmittance function, II: 344
 various properties, II: 348
 operational definition, VI: 284
- Beebe, L., I: 143, 153
- bete noir (in applied math), VI: 105, 263
- biological sources, underwater light field, I: 53
- blondel, I: 21, II: 179
- Bochner theory (of positive-definite functions) VI: 110,
- Boltzmann equation (for water waves), VI: 208
- Bouguer's work, III: 1
- boundaries, I: 55
 reflecting, II: 340
- boundary effects, V: 71, 46
- bounds, on radiance, III: 47
- Bretschneider's empirical wave observations, VI: 158
 wave spectrum, VI: 204
- Bright target technique (for α), VI: 292
 for α , σ_0 , VI: 299
- brightness (monochromatic) of radiant flux, I: 10
 "brightness" is an untechnical term for the precise concepts of radiance or luminance (as the case may be)
- candela, I: 20, II: 163, 179
- canonical equations
 sense of the term, III: 1
 classical, III: 91
 experimental verification, III: 13
 general media, III: 15
 stratified media, III: 18
 polarized radiance, III: 21
 abstract versions, III: 24
- canonical forms of transport equation for κ functions, V: 273, VI: 292
- canonical representation
 of apparent radiance, III, 16
 of abstract functions, III, 27
 of irradiance fields, V: 98
 of α (attenuation function), VI: 292
- capillary waves, VI: 71
- cardioidal radiance distribution, VI: 21
- carnivores (in food chain), I: 199
- catalog of K-figurations (shallow depth theory), V: 201
 nondegenerate
 degenerate
 first, second kind
 forbidden, V: 202
- categorical synthesis method, IV: 164
- cauchy sequence, III: 130
- causality conditions, (for R,T), IV: 23

- characteristic
 representation of $N(y)$,
 IV: 122
- characteristic ellipsoid
 spheroid, III: 66, 68
- characteristic equation
 for second order differ-
 ential equation, V: 39
 for K function, V: 123, 252
- chromaticity (color), I: 146
 components, I: 148
 plane, I: 147
 diagram, I: 149
 coordinates, I: 149
- Clairaut's equation (for in-
 verse n^{th} power irradi-
 ance law), II: 126
- classical diffusion theory,
 III: 134
 basic diffusing equation,
 III: 175
 radiance distribution in,
 III: 181
 approaches via higher order
 approximations, III: 183
 hierarchy of processes, III:
 184
 plane-parallel solutions,
 III: 193
 spherical (point) solutions,
 III: 200
 discrete (extended) solu-
 tions, III: 203
 continuous (extended) solu-
 tions, III: 206
 primary sources, III: 207
 for higher order scattered
 scalar irradiance, III: 213
 time dependent, III: 214
- classical models for irradi-
 ance fields, V: 19
 collimated-diffuse light
 fields, V: 19
 isotropic scattering models,
 V: 23
 connections with diffusion
 theory, V: 24
- classical spherical harmonic
 method, plane-parallel
 media, III: 158
- classical theory, inadequacies,
 V: 115
- classification of natural
 hydrosols, I: 138
- coherent (partially) radiance
 field (problem), VI: 346
- colligation of component ψ -
 operators, IV: 176
- collimated flux
 scattering functions for,
 I: 83
 produced by sources, I: 114
- color
 components, I: 146
 purity, I: 149
 dominant wavelength, I: 149
- colorimetric radiative trans-
 fer, I: 142
- commutativity (of R, T, ρ, τ),
 IV: 34
- complete (general) solution
 of irradiance equations,
 V: 42
- complete metric space, III:
 131
- complete (Planckian) radiator,
 II: 162
- complete reflectance (for
 irradiance), I: 79, V: 4,
 4, 79, 62, 64
- complete transmittance (for
 irradiance), I: 79, V: 4,
 62, 64, 79
- completeness property of
 spherical harmonics, III:
 142, 153
- cone (in space time), III: 53
- consistency
 check for inherent optical
 properties, I: 124
 check for operational for-
 mulations, VI: 339
 of unpolarized radiative
 transfer theory, VI: 341
 experimental check for un-
 polarized radiative trans-
 fer in a polarized setting,
 VI: 345
- constitutive definitions, II:
 8
- constructive extension of
 $\mathcal{M}(x, y, z)$, IV: 50
- continuous sources in diffu-
 sion theory, III: 206
- contraction mapping, III: 129
- contraction mapping, princi-
 ple of, III: 131
- contraction property (of beam
 transmittance), II: 348,
 III: 129
- contrast
 apparent inherent, I: 44,
 V: 165
 transmittance law, I: 89,
 90, 99

- contrast--Cont'd.
multiplicative (semigroup)
property, I: 95
contrast reduction
subsurface, by scattering
and absorption, I: 44
by refractive effects,
I: 48
contrast transmittance, V: 162
properties, V: 168
in canonical equation for
radiance, V: 170
alternate representations,
V: 171
as an apparent optical
property, V: 172
effect of shadows on, V: 174
at static air-water
surface, VI: 41, 44
at dynamic air-water
surface, VI: 258
contravariation of K and D,
V: 144
conventions (used in this
work)
nature of radiant flux, I: 6
unpolarized-flux, I: 7
frequency density (footnote)
convexification, white, black
II: 316
convolution theorem (of inte-
gral transform), IV: 192
applied to energy spectrum,
VI: 98
coordinate systems, terres-
trial, II: 19
cosine collector, II: 7
cosine law, for irradiance,
I: 13, II: 26
for radiant emittance, I: 14
cosine (mean value $\bar{\mu}$), III: 180
cosurface time average, III:
238
covariation of K and D, V:
128, 136, 140
rule of thumb, V: 145
Cox and Munk's wave slope
observations, VI: 145
dark target technique (for N_*),
VI: 289
for α , VI: 291
for α , σ_0 , VI: 300
decomposed (diffuse) irradi-
ance, V: 14
decomposed (light field),
I: 63
radiometric functions,
III: 36
decomposed (light field)--
Cont'd.
equation of transfer, IV:
9, 14
definitions: constitutive,
operational, II: 8
depth (in a reference
frame), II: 19
derivative property (of
integral transform), IV:
192
dichroic material (and
polarized light), II: 84
differential equations
for $\mathcal{M}(x,y)$, IV: 69
for $\mathcal{M}(x,y,z)$, IV: 71
for $\mathcal{M}(v,x;u,w)$, IV: 76
for $M(x,y)$, IV: 79
for $\Psi(s,y)$, IV: 79
for $R(y,b)$, IV: 80
for dual operators, IV: 173
diffraction, limits on
radiometry, II: 16
diffuse absorption coeffi-
cient, V: 111
diffuse (decomposed) irradi-
ance, V: 14
transmittance for, V: 17
diffuse radiometric func-
tions, III: 36
stored energy, III: 123
diffusion constant (D), I: 64
in terms of K, I: 111
in terms of κ , III: 194
diffusion equation
scalar, III: 174
wave, III: 184
tensor, etc., III: 184
for h, I: 64
diffusion function (D), III:
174, 180, 181
diffusion length, I: 135
III: 196
diffusion model, I: 61
for point sources, I: 110
empirical examples, I: 112
diffusion processes
a short list, III: 184
diffusion theory, three
approaches, III: 172
diffusion theory, connections
with, V: 24
see also *exact*, below
dimensionless forms of radi-
ant energy fields, III: 97
Dirac matrices, V: 8
direction, defined, II: 19
upward, downward, II: 21

- direction, defined--Cont'd.
 unit inward, II: 25
 for reflectance and transmittance, II: 212
- directly observable
 radiant energy, equation of transfer, III: 81
 optical properties, V: 109, 178
- directly transmitted radiance, II: 347
- discrete sources in diffusion theory, III: 202
- discrete-space radiative transfer, V: 51
- displacement law (in ocean wave theory), VI: 186
 analogous to Wien's law
- distribution factor, I: 55
- distribution function,
 origin, V: 10
 for diffuse irradiance, V: 15
 representative values, V: 26
 representation via radiance distribution, V: 27
- depth dependence, V: 26
 in canonical equation for irradiance, V: 99
- experimental, V: 115
- contravariation (with κ -function), V: 144
 covariation (with κ -function), V: 128, 136, 140
- physical and geometrical features, V: 128
 asymptotic limits, V: 246
 summary discussion of properties, VI: 329
- divergence law for vector irradiance, I: 44, 64
- dominant wavelength, I: 149
- dual operators
 first appearance, IV: 156
 second appearance, IV: 158
 definitive list, IV: 160
 for invariant imbedding relation, IV: 166
 integral representation, IV: 167
 differential equations for, IV: 173
- Duntley disks, I: 96
- Duntley's wave slope observations, IV: 138
- ϵ (epilson) function, III: 222
- Eckart's wave generation model, VI: 207
- electric circuit analogy (with an optical medium) III: 77, 123
- electromagnetic view of light (vs. phenomenological), II: 13
- elsewhere (in space-time), III: 53
- empirical basis (of module equations), IV: 106
- empirical wave spectrum models, VI: 181
- energy conservation principle (for radiometry), II: 199
- energy of surface waves, VI: 72
 and wind speed, VI: 193
- energy spectrum, VI: 79
 see *spectrum*
- equation of continuity, VI: 50 *et seq.*
- equation of (fluid) notion, IV: 48 *et seq.*
 linearized, VI: 62
- equation of transfer, I: 60
 for radiance, II: 368
 time dependent and polarized form, II: 371
- n-ary radiance, III: 36
- unscattered radiance, III: 37
 diffuse radiance, III: 37
 path function, III: 38
 natural solution, III: 43, 127
 for optical ringing, III: 56
 solved symbolically, III: 65
- residual radiant energy, III: 76
- n-ary radiant energy, III: 80
- directly observable radiant energy, III: 81
- dimensionless (for radiant energy), III: 97
- scalar irradiance (diffusion equation), III: 175
 limitations (in group method) IV: 130
 as local form of principles of invariance, IV: 4
- scattered radiance, III: 209
- scattered scalar irradiance, III: 210, 213

- equation of transfer--Cont'd.
 for time-averaged radiance fields, VI: 239
 for perturbed light field, VI: 293
 in a polarized light field, VI: 344
- equilibrium radiance, I: 85, III: 6
- equilibrium radiance function, V: 151
 for radiance, V: 151
 for irradiance, V: 13, 265
 for scalar irradiance, V: 270
 for reflectance, V: 149, 279
 for K-functions, V: 275
 for other concepts, V: 281
- equilibrium-seeking theorem
 for R, V: 152
 for N,H,h, V: 270
 and universal radiative transport equation, V: 279
- equilibrium solutions (food chain), I: 203
- equivalence classes of functions, III: 128
- equivalence theorem for $R(z,-)$, V: 159
- ergodic cups and caps, VI: 263
- ergodic hypothesis, VI: 148
 and water wave slopes, VI: 261
- exact diffusion theory
 basic equation, III: 134, 190, 192, IV: 218
 infinite medium with point source, III: 219
 infinite medium with arbitrary sources, III: 225
 scalar irradiance, III: 226
 semi-infinite medium with boundary point source, with internal point source, III: 228, 233
 on the Elliott functional relations, III: 236, IV: 153
- exponential law of change (general), IV: 197
 differential form, I: 201
- exponential property of diffusion field (plane-parallel case), III: 194
- exponential representation of $M(y), N(y)$, IV: 117
 of $Q(y)$, IV: 117
- extension of operators, IV: 50
- Fick's Law (of diffusion), I: 64, III: 174
- field interpretations of radiant flux, I: 12
- fine structure of light field hypotheses, V: 199
 special relations, V: 208
- finite recurrence property, III: 147, 154
- finitely deep hydrosols, reflectance and transmittance, I: 68
- first order scattered radiance equation for, III: 41
- first standard solution of two-D model, V: 31
- fixed depth time average, III: 238
- floating buoy motion (for spectra), VI: 173
- fluid transfer process, VI: 47
- flux (see *radiant flux* or *luminous flux*)
- flux density (radiant), I: 10
- food chain problem (in the sea), I: 196
- foot candle, I: 20
- forward scattering functions, V: 11, 141
 experimental determination, VI: 335
- forward scattering media, V: 140
- Fourier integral representation of air-water surface, VI: 101
- Fourier series representation of air-water surface, VI: 87
- Fourier transform of exact diffusion equation, III: 192
- frames (of reference, e.g., terrestrial), II: 24
- frequency density convention (in this work), I: 7
- Fresnel's laws for reflectance VI: 10
- functional relations for f_c, f_o in exact diffusion theory, III: 236
- fundamental optical property, V: 107, 178
- future (in space time), III: 53
- gamma-type wave spectra laws, VI: 190

- Gelbstoff, I: 133
 geophysical optics, defined
 I: 1
 GEOVAC (geophysical optics
 variable automatic compu-
 ter), I: 208
 Gershun tube, VI: 282
 glitter patterns
 on air-water surface,
 I: 32
 photographed, VI: 147
 computed, VI: 254
 global approximations for
 radiance, III: 117
 higher order, III: 119
 global concepts, IV: 148
 global optical property,
 V: 107, 180
 measurement of R,T,
 VI: 331
 global Ψ -operators
 integral representation,
 IV: 162
 gravity waves, VI: 71
 group property (of integral
 transfer kernel), IV:
 191
 group structure of natural
 light fields, II: 307
 groups (method of), IV: 114

 Haidinger's brush (in pola-
 rized light), II: 84
 harmonic analysis,
 of dynamic air-water
 surface, VI: 82
 roots of, VI: 83
 vs. synthesis, VI: 84
 integrals vs. series, VI:
 86
 hydrodynamic basis, VI:
 91
 Hasselmann's wave spectrum
 theory, VI: 209
 heirarchy of time-averaged
 sea surface radiance
 models, VI: 250
 hemisphere (E_{\pm})
 herbivore (in food chain)
 I: 199
 herschel (luminance unit),
 I: 21, II: 172
 heterochromatic radiative
 transfer, IV: 197
 homogeneity (of σ), I: 82
 homogeneous (optical medium)
 IV: 144
 restricted, IV: 145

 Hulburt's wave slope observa-
 tions, VI: 136
 hydrodynamic basis of harmonic
 analysis of air-water sur-
 face, VI: 91
 hydrodynamics and radiative
 transfer, VI: 46
 hydrologic optics, defined,
 I: 1
 future problems, I: 205
 hydrologic range, I: 90

 illuminance, I: 19
 measured at earth's surface,
 I: 25, II: 166
 independence condition, VI:
 220
 index of refraction (relative)
 VI: 5
 inelastic scatter, III: 5
 inequality for κ, α , III: 195
 among optical properties,
 V: 114, 119
 infinitesimal generator, IV:
 112
 of Γ_2 , IV: 116
 inherent optical properties,
 I: 118,
 defined, listed, I: 119,
 V: 106, 178, 180
 inherent radiance, I: 60,
 II: 363
 inner structure of natural
 light fields, IV: 141
 integral equation for scalar
 irradiance, III: 189
 integral representations of
 local Ψ -operators, IV:
 154
 of global Ψ -operators,
 IV: 162
 of dual operators, IV: 167
 integral transform techniques
 IV: 188
 group property, IV: 191
 derivative property, IV: 191
 convolution theorem, IV: 191
 for time-dependent radia-
 tive transfer, IV: 194
 integrating sphere, II: 262
 intensity (radiant), I: 10,
 II: 70
 field, I: 12
 surface, I: 12
 luminous, II: 166
 interaction functional (for
 wave spectrum), VI: 208

- interaction method
 a first synthesis, II: 222
 in other fields, II: 223
 (in footnote)
 summary, II: 388
 and quantum theory,
 II: 390
- interaction operators
 integral structure, II,
 372
 kernel, II: 380
 see also *operators*
- interacting media (invariant
 imbedding operators for)
 V: 76
 air-water surface and hy-
 drosol, VI: 35
 threefold irradiance in-
 teraction (air, water,
 air-water surface), VI:
 38
 threefold radiance inter-
 action, VI: 39
 time-averaged radiance
 fields (air-water),
 VI: 246
- interaction principle, I: 4
 physical basis, II: 189
 basic statement, II: 205
 place in radiative trans-
 fer theory, II: 208
 levels of interpretation,
 II: 208
 Ambarzumian's principle,
 II: 228, IV: 34
 applications to plane sur-
 faces, II: 217
 applications to curved
 surfaces, II: 258
 applications to plane-
 parallel media, II: 285
 applications to general
 spaces, II: 322
 on one-parameter media
 with sources, II: 330
 as basis for beam trans-
 mittance and volume
 attenuation function,
 II: 344
 as basis for path func-
 tion, path radiance, II:
 351
 as basis for volume
 scattering function, V:
 364
 as basis for equation of
 transfer, II: 368
- interaction principle--Cont'd.
 as a means and as an end,
 II: 391
 for time-averaged sea radi-
 ance, VI: 246
- interdependence (plan) of
 chapters on this work,
 I: 5
- interfaces, reflecting, V: 340
- internal-source problem,
 IV: 152
 new methods, V: 102
- internal sources and irradi-
 ance fields, V: 37, 55, 81
- interreflection calculations
 terminable and nontermin-
 able, II: 248
- invariant imbedding relation,
 I: 71, 80
 on plane parallel media,
 II: 297
 historical notes, II: 299
 generalized form, II: 301
 for one-parameter media,
 II: 327
 in general media, II: 339
 time dependent, IV: 22
 algebraic properties, IV: 35
 analytic properties, IV: 68
 for deep hydrosols, IV: 104
 dual form, IV: 166
 for irradiance fields, V:
 2, 61
 in two-D model, V: 36
 including boundary effects,
 V: 50
 for interacting media, V:
 76
- inverse problems in hydrologic
 optics, VI: 339
- invertibility of operators,
 IV: 39
 application to N from H,
 II: 145
- irradiance, I: 12
 scalar, I: 15, 106, II: 54
 hemispherical scalar, I: 16
 vector, I: 15
 net, I: 16, 61, II: 26
 upwelling (upward), I: 16,
 55, 58, 106
 downwelling (downward), I:
 16, 55, 58, 106
 measured at earth's surface
 I: 24
 reflectance of air-water
 surface, I: 30

- irradiance--Cont'd.
 reflectance in deep water,
 I: 67
- invariant imbedding
 relation, I: 71
 defined, II: 14, 171,
 III: 274
 meaning, II: 16
 typical orders of
 magnitude, II: 17
 in terrestrial frames,
 II: 24
 upward, downward, II: 24
 cosine law for, II: 26, 66
 (from radiance), II: 35, 131,
 138
 radiance from II: 41
 spherical, II: 56
 vector, and mechanical
 analogy, II: 62
 janus plate (for net),
 II: 68
 -distance law (for
 spheres), II: 103
 -distance law (for
 circular disks, II: 105
 -distance law (for general
 surfaces), II: 106
 via line integrals, II: 109
 via surface integrals,
 II: 115
 laws of the form $1/r^n$,
 II: 120
 distributions, equivalence
 of with radiance distribu-
 tions, II: 143
 computation for parallel
 planes, II: 217
 on plane-parallel media,
 II: 286
 vector, via spherical
 harmonics, II: 177
 scalar, via higher order
 scattering, III: 213
 (see also *scalar irradiance*,
vector irradiance)
 interaction equations at
 air-water surface, VI: 38
- irradiance distributions,
 underwater, I: 42
- irradiance (two-flow) equa-
 tions, V: 6
- irradiance quartet, I: 135,
 V: 115, VI: 325
- isomorphism between Γ_2, G_2
 IV: 44
- isotropic (optical medium),
 IV: 147,
 process, IV: 147
- isotropic scatter, IV: 83, 86
- isotropic scattering (in vec-
 tor light field model),
 V: 94
 models, V: 23
- isotropy (of σ), I: 82
- iterated operators, II: 236
- janus plate, II: 68
- Jordan canonical form IV: 122
- joule, II: 172
- κ (kappa) K-function or dif-
 fuse attenuation function
 for diffusion model),
 I: 65, III: 194
- κ_0 (dimensionless form)
 III: 271
- k (little kay), I: 58
 interchangeable with K (big
 kay), I: 83
- K-function
 general, III: 15
 two-D model, V: 31, 39
 one-D model, V: 53, 56
 in canonical equation, V:
 100
 theoretical form, V: 111
 diffuse absorption coeffi-
 cient, V: 111
 experimental, V: 115
 significance of sign, V: 120
 characteristic equation for,
 V: 123
 connections among (irradi-
 ance K-function), V: 123
 general forms, V: 125
 for radiance, V: 125
 integral representations,
 V: 126
 in spherical coordinates,
 V: 127
 contravariation (with dis-
 tribution function), V:
 144
 covariation (with distribu-
 tion function), V: 128,
 136, 140
 physical and geometrical
 features, V: 128
 absorptionlike character
 (for irradiance), V: 138
 configurations for shallow
 depths, V: 201
 asymptotic limits, V: 246
 canonical form of transport
 equations for, V: 273
 discussion of experimental
 history, VI: 330

- K_{α} , III: 188
 K_{κ} , III: 214
 K_{ϵ} , III: 221
 Kelvin-Helmholtz model,
 VI: 67, 206
 instability, VI: 70
 kernel
 interaction, II: 380
 of integral transform
 IV: 191
 Koschmieder's equation,
 III: 5

 l.i.m., VI: 104
 lagrangian (a mobile or sub-
 stantial) derivative,
 I: 371, VI: 49
 lambert, I: 20
 transmitter or reflector,
 II: 262
 laminar flow model (of wave
 generation), VI: 206
 law of reflection (at water
 surface), VI: 3
 law of refraction (at water
 surface), VI: 5
 light
 this term is used throughout
 the present work as an in-
 formal correspondent to any
 one of the defined concepts
 of geometrical radiometry
 and photometry. The mean-
 ing intended for the term
 light will be implicit in
 each context of its use.
 Thus *light field* may, e.g.,
 correspond informally to
 radiant energy, radiant
 flux, radiance distribution
 irradiance function, lumi-
 nous energy, luminous flux,
 luminance distribution,
 illumination function, et-
 cetera.
 light field
 decay with depth, I: 37, 66
 polarization, underwater,
 I: 50
 biological sources, I: 53
 artificial, I: 109
 decomposed, I: 63
 time dependent, III: 49,
 IV: 17
 inner structure, IV: 141
 fine structure, V: 199, 208
 perturbed, VI: 293
 light storage phenomena in
 natural optical media,
 III: 121
 linear functional, II: 373
 positive, II: 375
 line of flux, II: 8
 local optical property, V:
 107, 179, 180
 operational determination,
 VI: 333, 335
 local principles of invari-
 ance, IV: 18
 local Ψ -operators, IV: 154
 local reflectance, IV: 3,
 V: 7
 local residual (reduced)
 transmittance operators,
 IV: 11
 local transmittance, IV: 3,
 V: 7
 logarithmic wind profile,
 VI: 132
 logical descendents of Ψ ,
 IV: 171
 lumen, I: 19, II: 161, 179
 luminance, I: 19,
 distribution, relative,
 II: 156
 distribution, general, II:
 163, 166
 typical magnitudes, II: 164
 path, II: 179
 luminosity of a wavelength,
 II: 153
 luminosity function,
 standard, II: 151, 157, 159,
 160
 for individuals, II: 153
 photopic, I: 145, II: 155,
 158
 scotopic, II: 155
 relative (of radiance),
 II: 157
 generalized, II: 184
 luminous emittance, II: 166,
 179
 scalar, II: 168, 179
 vector, II: 179
 luminous energy, I: 19, II:
 167
 luminous energy density, II:
 167
 luminous flux, II: 166
 luminous intensity, II: 166
 luxoid (via inverse nth power
 for irradiance), II: 130

 mpq, VI: 120

- $m\mu$ (millimicron)
 (= nanometer, nm), II: 192
 manhole (optical), I: 34
 many-D models, V: 57
 mean square
 wave elevation, VI: 120
 wave slopes, VI: 121
 measure, Riemann, Lebesgue,
 Stieltjes, II: 12
 illustration of, II: 373
 basic theorems, II: 375
 interaction, II: 380
 media
 plane-parallel, cylindrical,
 etcetera, see *table of contents*
 melanoidines (Gelbstoff),
 I: 133
 meter, radiance, II, 30
 for polarized radiance,
 II: 85
 method of modules, IV: 103
 semigroups, IV: 108
 groups, IV: 114, 129, 135,
 141
 for irradiance fields,
 V: 80
 metric
 supremum, III: 129
 radio-, III: 128
 metric space, III: 127
 complete, III: 131
 Miles' wave generation model,
 III: 207
 millimicron ($m\mu$), = 10^{-9} m
 = nanometer, II: 192
 mobile (or substantial or
 lagrangian) derivative
 I: 371, VI: 49
 möbius strip, II: 271
 modes of classification of
 natural hydrosols, I: 140
 modules (method of), IV: 103
 equations, IV: 106
 monotonicity condition on
 radiance distribution,
 V: 28
 moon
 radiance of, II: 98
 radiant intensity of, II: 99
 luminance of, II: 164
 multiplicative (semigroup)
 property
 of contrast transmittance,
 I: 93
 of beam transmittance,
 I: 120, II: 348
 n-ary radiometric concepts,
 III: 31
 radiance, III: 33
 scalar irradiance, III: 34
 radiant energy, III: 34, 83
 general, III: 35
 canonical equation for
 radiance, III: 38
 natural closed forms for
 radiant energy, III: 86
 time-dependent properties,
 III: 89
 dimensionless forms, III:
 97
 n^2 -convention, VI: 210
 nanometer (= 10^{-9} m) = milli-
 micron ($m\mu$), II: 192
 natural hydrosols
 classified, I: 138
 characterization (for
 visibility), I: 195
 natural illumination, I: 156
 natural (mode of) solution,
 II: 203, 247
 for radiance, III: 42
 truncated, III: 45, 69
 time-dependent, III: 58
 symbolic integration,
 III: 65
 for directly observable
 radiant energy, III: 82
 time-dependent properties,
 III: 90,
 dimensionless form, III: 97
 operator-theoretic basis,
 III: 127
 for scalar irradiance, III:
 191
 Neumann spectrum, VI: 181
 nomographs for underwater
 visibility, I: 154
 norm-contracting property,
 of C operator, II: 147
 of R, T operators, II: 236
 of operators, II: 322
 normal space ($0 < \rho < 1$),
 III: 103
 normal operator algebra, II
 243
 north-based reference frame,
 II: 19
 nutrient (in food chain), I
 199
 one-D (two-flow irradiance)
 model, I: 56
 one-D models for irradiance
 fields, V: 51

- one-D models for irradiance fields--Cont'd.
 for undecomposed fields, V: 52
 internal sources, V: 55
 for decomposed fields, V: 56
 connections with observable fields, V: 160
 one-path method (for beam transmittance), VI: 286
 ontogeny (family roots) of two flow equations, V: 13
 operational definitions of the densities, I: 10, II: 8
 principal radiometric concepts, VI: 273
 operator-theoretic basis for natural solution, III: 127
 operators
 algebra, II: 230
 iterated, II: 236
 algebra and radiative transfer, II: 241
 algebra, normal, II: 243
 , , II: 319
 interaction, structure of, II: 372
 volume transpectral, II: 386
 path function, II: 383
 path radiance, II: 384
 interaction for general spaces, II: 314, 378
 interaction for surfaces, II: 377
 miscellaneous examples, II: 387
 R (path function), III: 32
 T (path radiance), III: 32
 S (radiance), III: 33
 time dependent, III: 68
 contraction, III: 129
 U (scalar irradiance), III: 129
 V (= TU), III: 188
 optical length, III: 270, IV: 146
 optical medium
 transparent, III: 3
 absorbing, III: 3
 fundamental, III: 5
 electric circuit analogy, III: 77
 as a metric space, III: 132
 light storage, III: 121
 one parameter, IV: 142
 homogeneity, isotropy and related properties, IV: 143 *et seq.*
 optical medium--Cont'd.
 with internal sources, IV: 152
 definition (formal), V: 108
 optical properties
 inherent, apparent, I: 118
 II: 349
 local global, V: 107
 fundamental, V: 107
 general definition, V: 109
 directly observable, V: 109
 classification, V: 178
 in asymptotic light fields, V: 238
 optical reverberation case, III: 86
 optical ringing problem, one-dimensional, III: 49
 three-dimensional, III: 66
 optical volume, III: 220

 parseval identity, VI: 105
 partially coherent polarized radiance fields (theory formulation problem), VI: 346
 partition relations, IV: 28
 past (in space-time), III: 53
 path function (radiant), I: 60, II: 172
 (luminous), II: 179
 derivation, II: 351
 connection with path radiance, II: 354
 integral representation, II: 367
 operator, II: 383
 equation of transfer, III: 38
 operational definition, III: 287
 path luminance, II: 179
 path radiance, I: 63, 172
 derivation, II: 351
 connection with path function, II: 354
 operator, II: 384
 first-order form, III: 11
 operational definition, VI: 287
 Pauli matrices, II: 8
 perfectly diffusing (surface) I: 21
 periodogram (basis of energy spectrum), VI: 94
 perturbed light fields (general theory), VI: 293
 experimental procedures, VI: 302

- phase density, of radiant flux, I: 10
 phase function, IV: 146
 polarized, VI: 343
 phase space density, II: 9
 phenomenological, view of light (vs. electromagnetic), II: 13
 photoelectric effects (photoelectric cells, photoemissive, photoconductive, photovoltaic), II: 3
 photometry, geometrical, I: 18
 II: 2, 165
 generalized, II: 183
 nonlinear, II: 185
 photon,
 as viewed in this work, I: 7
 as an aid to visualization, II: 10
 entering an eye from a star, II: 18
 photopic luminosity curve, I: 18, 145
 phytoplankton (in food chain) I: 199
 planckian (complete) radiator, II: 162, VI: 182
 Planck's quantum of action, II: 9
 plane of incidence (in reflection and transmission at water surface), VI: 3, 5
 plane of scattering, II: 91
 plane-parallel medium, I: 55
 see also *table of contents*
 point source
 operational definition, II: 75
 criterion for, II: 105
 in classical diffusion theory, III: 198
 in exact diffusion theory, III: 219
 polar (optical medium), IV: 150
 polarity (of R,T), IV: 26, V: 34
 polarity theorem, IV: 150
 polarization, defined, I: 50
 underwater properties, I: 52
 convention, II: 194 (footnote)
 scattering function measured VI: 314
 problem of coherent electromagnetic fields VI: 346
 polarized equation of transfer, II: 371, VI: 342
 polarized radiance
 canonical representation, III: 19
 asymptotic properties, IV: 128
 in a coherent electromagnetic field, VI: 346
 Poynting vector field, II: 9
 prey-predator equations, I: 198
 primary radiance, equation for, III: 41
 primary scattered flux as source flux, III: 207
 primary scattered irradiance, V: 43
 principles of invariance
 for irradiance, I: 73, 79
 on plane parallel media, II: 294
 on spherical, cylindrical, toroidal media, II: 325
 on general media, II: 336
 local form (equation of transfer), IV: 4
 diffuse form, IV: 14, 15
 time-dependent form local IV: 18
 time-dependent form global, IV: 23
 for complete operators, IV: 48
 global (for irradiance) V: 2
 local (for irradiance), V: 7
 for diffuse irradiance, V: 18
 problems of hydrologic optics, I: 2, 205
 Ψ -operator (for internal sources) (basic definitions in Example 3, Sec. 3.9)
 connection with an operator, IV: 53
 differential equation, IV: 79
 purely absorbing medium, III: 3
 quantum, I: 7
 quantum mechanics
 formal similarity with, V: 8
 quantum-terminable calculations, II: 254
 quantum theory and interaction method, II: 370
 quasi-irrotational light field, V: 88
 quasi-steady state (food chain), I: 202

- R-infinity (R_∞), I: 67
 correction in visibility,
 I: 172
 formulas, V: 113
- radiance, I: 10
 field, I: 12
 surface, I: 12
 inherent, I: 60
 apparent, I: 60
 equilibrium, I: 85
 -difference law, I: 92
 empirical definition,
 II: 30, 171, VI: 281
 meter, II: 30, 85
 theoretical, II: 32
 via photon density, II: 33
 typical values, II: 33, 34,
 97
 distributions (on \mathbb{E}), II: 34
 function (on $X \times \mathbb{E}$), II: 34
 irradiance from, II: 35
 (from irradiance), II: 41
 field vs. surface, II: 44
 invariance property, II: 46
 radiance-invariance law,
 II: 46
 operational meaning of sur-
 face radiance, II: 49
 n^2 -law, I: 18, 87, II: 51
 polarized, II: 83
 std. Stokes vector, II: 88
 std. observable vector, II:
 88
 polarization composition
 theorem, II: 89
 local observable vector,
 II: 91
 radiant flux content of
 polarized, II: 94
 distributions, elliptical,
 II: 131
 distributions, polynomial,
 II: 139
 distributions, equivalence
 of with irradiance distri-
 butions, II: 143
 path, I: 63, II: 172
 D'-additivity (surfaces),
 II: 195
 D'-continuity (surfaces),
 II: 195
 of parallel planes, II: 244
 D'-additivity (slabs), II: 282
 D'-continuity (slabs), II:
 282
 on plane-parallel media,
 II: 290
 in transparent media, III: 2
- radiance--Cont'd.
 in absorbing media, III: 3
 equilibrium, III: 6
 maximum (Natural waters),
 III: 12
 transmittance, III: 14
 polarized, III: 19
 residual (reduced, unscat-
 tered), III: 31
 n-ary (primary, secondary,
 etc.), III: 33
 natural solution for, III: 42
 bounds, III: 47
 global approximations, III:
 117
 distribution in diffusion
 theory, III: 119, 181, 197,
 201
 directly transmitted, I: 347
 residual, I: 120, II: 347
 unattenuated, II: 347
 characteristic representa-
 tion, IV: 125, 126
 polarized (asymptotic), IV:
 128
 equilibrium, V: 151
 transmittance, V: 164
 multiplicity of representa-
 tions, V: 177
 interaction at air-water
 surface, VI: 39
 time-averaged interactions
 at surface, VI: 253
 partially coherent, VI: 346
- radiance distribution
 behavior with depth, I: 39
 asymptotic hypothesis, I: 41
 by submerged point source,
 I: 113
 at air-water surface, VI: 40
 integral equation for air-
 water surface (instantane-
 ous), VI: 215
 integral equation for air-
 water surface (time aver-
 aged), VI: 223
 instantaneous and time
 averaged within hydrosol,
 VI: 237
 partial time averaged
 theories, VI: 253
- radiance model (classical)
 I: 58
 neo-classical (air-water
 surface), VI: 253
- radiant density, I: 16
 II: 54, 172
- radiant emittance, I: 12, 28, 171

- radiant emittance--Cont'd.
 empirical, II: 29
 scalar, II: 61
 vector, II: 171
 radiant energy
 In this total work either radiant energy or radiant flux may be the undefined, primitive concepts, taken as given by nature and axiomatized by radiometrists as their primary physical notions. In other fields, such as electromagnetics, they can be made to rest on one step lower: on the constructs (E,D,B,H) of the electromagnetic field. These steps into physical primitivity descend even lower. But this nether region is of no concern to us in this work. See footnote, p. 32, Vol. II for the local choice of ϕ or U as the more primitive notion.
 radiant energy, II: 54, 172
 over space, II: 60
 over time, II: 61
 n-ary, III: 34, 83
 residual representation, III: 79
 equation of transfer for n-ary, III: 81
 natural closed form representation, III: 86
 optical reverberation case, III: 86
 standard growth and decay case, III: 87
 time dependent properties, III: 89
 scattered, absorbed, attenuated, III: 93
 stored, III: 123
 time dependent (check), III: 216
 radiant flux, defined, I: 7
 monochromatic brightness of, I: 10
 field and surface interpretations, I: 12
 operational definition, II: 2, 7, 171, IV: 274
 calculations, II: 117
 meaning, II: 8
 F-additivity, II: 10
 radiant flux--Cont'd.
 F-continuity, II: 11
 monochromatic (or spectral), II: 11
 finite vs. countable additivity, II: 11
 S-additivity, II: 12
 S-continuity, II: 12
 D-additivity, II: 13
 D-continuity, II: 13
 net inward, III: 76
 source, III: 76
 net n-ary, III: 80
 radiant intensity
 field and surface, I: 10, 12
 empirical definition, II: 70, 171
 field vs. specific, II: 72
 theoretical, II: 73
 point sources and, II: 74
 cosine laws for, II: 77, 80
 vector, II: 81
 area-law for general surfaces, II: 119
 radiative process defined, II: 190
 radiative transfer analogies, III: 77, 133
 radiative transfer theory, defined, I: 1
 basic constructs, I: 4
 atmospheric features, I: 27
 across air-water surface, I: 28
 colorimetric, I: 142
 as based on the interaction principle, II: 188
 and operator algebra on a metric space, III: 132
 heterochromatic, IV: 197
 multidimensional, IV: 198
 across static air-water surface, VI: 34
 and hydrodynamics, VI: 46
 radiator, planckian or complete, II: 162
 radiometric (as a metric), III: 128
 radiometric concepts, operational definitions, I: 11
 radiometric functions
 general n-ary, III: 35
 diffuse, decomposed, III: 36
 radiometric norm, II: 146, 232
 radiometric-photometric transition operator, II: 166, 169
 radiometrically adequate collector, II: 151

- radiometry, geometrical, I: 7,
 II: 2
 transition to photometry,
 II: 166
 mathematical basis of,
 III: 169
 Radon-Nikodym
 theorem II: 185
 derivative, II: 376
 random surface, realization
 of, VI: 115
 rationalized units (polemic
 on), I: 21
 Rayleigh scattering, I: 132,
 VI: 21
 Rayleigh wavelength distribu-
 tion (for sea waves), VI:
 203
 reciprocal (optical medium),
 IV: 151
 reciprocity theorem, IV: 151
 reduced (residual irradiance)
 V: 15
 reference frame, terrestrial,
 II: 20
 stratified, II: 24
 local vs. standard (in pola-
 rized context), II: 91
 reflectance
 for irradiance at air-water
 surface, I: 30
 for infinitely deep homoge-
 neous water, I: 67
 for finitely deep homogene-
 ous water, I: 68
 complete (for irradiance),
 I: 79
 empirical, for surfaces, II:
 194
 operators, for surfaces,
 II: 210
 theoretical, for surfaces,
 II: 213
 lambert, II: 215
 algebra of operators, II:
 230
 operators for plane-parallel
 media, II: 279
 semigroup properties,
 II: 300
 in diffusion theory, III:
 198, 202
 local, IV: 3
 differential equations, IV:
 6, 8, 25, 26, V: 65, 79,
 123, 148
 causality condition, IV: 23
 algebraic properties, IV: 27
 reflectance--Cont'd.
 regularity properties,
 IV: 32
 asymptotic properties,
 IV: 33
 analysis of differential
 equation for, IV: 80
 partition relations, IV:
 28
 connections with invariant
 imbedding operator, IV:
 82
 solution procedures, IV:
 97, 83
 dual (complete), IV: 160
 for irradiance (undecom-
 posed), V: 3
 in two-D model, V: 33, 35,
 45
 complete (two-D), V: 62
 complete (one-D), V: 64
 R_{∞} formulas, V: 113
 experimental, V: 115
 connections with attenuat-
 ing functions, V: 118
 analytic representation,
 V: 146
 equilibrium-seeking prop-
 erty, V: 150
 integral representations
 of $R(z, -)$, V: 156, 196
 equivalence theorem for
 $R(z, -)$, V: 159
 equilibrium and attenua-
 tion functions, V: 149
 asymptotic limits, V: 246
 of static water surface
 (Fresnel), VI: 3, 13
 internal and external,
 VI: 16
 under cardioidal radiance
 distribution, VI: 21
 $r_{-}(m, n)$, VI: 26
 under zonal radiance dis-
 tributions, VI: 28
 discussion of operational
 properties, VI: 327
 operational determination,
 VI: 337
 refraction, subsurface, I:
 33
 regular neighborhoods of
 paths, V: 166
 regularity properties (of
 R, T), IV: 32
 relative error in radiance
 computations, III: 48
 relative time, III: 99

- residual radiance, I: 20, 63
 II: 347, III: 31
 phenomenological interpretation, II: 349
 transfer equation, III: 74
 radiant energy, III: 79
 residual (reduced) irradiance
 V: 15
 residual (reduced) transmittance, IV: 11
 restricted homogeneity, IV: 145
 reverberation, optical, III: 49
 reversible (optical medium), IV: 148
 Riccati equation in food
 chain, I: 203; for R, IV: 6
- σ (sigma), I: 122
 s (ess), I: 58
 SWOP (stereo wave observation project), VI: 167
 scalar diffusion equation,
 III: 174
 higher order form, III: 213
 scalar illuminance, II: 167
 scalar irradiance, II: 54,
 III: 11
 n-ary, III: 34, 217
 equation of transfer (diffusion equation), III: 175
 integral equation, III: 189
 scattered (equation formula),
 III: 210, 218
 higher order (equation formula), III: 213
 integral form, III: 214
 time-dependent n-ary (diffusion equation), III: 216
 exact diffusion theory,
 III: 226
 operational definition, VI: 278
 scalar luminous emittance,
 II: 168
 scatter processes (Rayleigh, Compton, etc.), II: 191
 inelastic or transpectral,
 III: 5
 single, III: 10
 scatter time constant, III: 81
 scattered flux, I: 58,
 for collimated flux, I: 83
 forward, backward, I: 124
 higher order, III: 211
 scattered radiance, equation
 of transfer, III: 209
 scattered radiant energy,
 III: 94
 scattered scalar irradiance
 equation of transfer, III: 210
 scattering
 plane of, II: 91
 standard function, II: 318
 scattering-attenuation ratio,
 III: 10, IV: 86, 148
 scattering functions (for
 irradiance),
 forward, backward, V: 11,
 141
 total, V: 12
 for decomposed irradiance,
 V: 16
 forward scattering media,
 V: 140
 scattering-order decomposi-
 tion, III: 30
 Schooley's wave slope obser-
 vations, VI: 151
 Schuster, A., I: 57
 sea state meter, VI: 139,
 260
 sea state simulator, VI: 261
 sea surface radiance distri-
 bution (time-averaged
 theories), VI: 250
 exact time-averaged theory,
 VI: 251
 statistical time-averaged
 theory, VI: 251
 wave-slope, wave height
 time-averaged theory,
 VI: 251
 wave slope, time-averaged
 theory, VI: 252
 partial time-averaged
 theories, VI: 252
 Secchi disk, I: 96
 in visibility calculations
 I: 169
 second standard solution of
 two-D model, V: 34
 "Seeliger's formula," III:
 132
 semigroup (multiplicative)
 properties
 of reflected and trans-
 mitted radiance flux,
 II: 300
 of $\Gamma_2(a,b)$, II: 309
 of $\Gamma_3(a,b)$, II: 298, 301
 of $\Gamma_4(a,b)$, II: 303, 312
 connections among Γ_3, Γ_4 ,
 II: 313

- semigroup properties--Cont'd.
of beam transmittance,
I: 120, II: 348
of τ , IV: 56
method of, IV: 108
infinitesimal generator,
IV: 112
for reflectance and transmittance, I: 95, V: 169
in fluid dynamics, VI: 46, 270
separable (optical medium),
IV: 145
shallow depth theory (of irradiance field)
experimental basis, V: 187
formulation, V: 193
comparison with experiment,
V: 197
shear flow model (of wave generation), VI: 207
sheltering model (of wave generation), VI: 206
sighting range (interpretation) I: 193
significant wave height (and period), VI: 159
simple model for radiance,
I: 61
for polarized light fields,
III: 21
eventual exactness, V: 249
sinusoidal wave forms, VI: 60
Snell's law, VI: 5
solar (irradiance) constant,
I: 22
(illuminance), I: 22
solid angle, II: 37
subtense of surfaces, II: 112
S-additivity property,
II: 114
S-continuity property,
II: 114
and the foundations of
Euclid's optics, II: 115
source term (for scalar irradiance), I: 64
sources
in one parameter media,
II: 330
of light fields, IV: 152
space light (= path radiance),
II: 363
space-time diagrams, III:
51 *et seq.*
specific intensity (see
radiance, surface), II: 44
specific radiance, II: 44
spectral transport theory,
VI: 208
spectrum
of air-water surface,
VI: 78
energy, VI: 79
density, VI: 81
periodogram basis, VI: 94
integrated, VI: 107
unresolved, VI: 111
amplitude, VI: 115
resolved, VI: 117
difference, VI: 119
geometrical application,
VI: 120
 $S(k, \phi)$, VI: 126
 T_k , VI: 126
 $F(\sigma, \phi)$, VI: 128
 T_τ , VI: 129
 T_σ , VI: 129
data on waves, III: 166
co-and quadrature, VI: 176
empirical models, VI: 181
Neumann, VI: 181
the remarkable trio of laws
analogous to thermodynamic-
radiative laws, VI: 186
alternate forms of one-
dimensional laws, VI: 189
gamma type, VI: 190
and wind speed, VI: 193
theoretical models, VI:
194
wave elevation distribution,
VI: 194
wave slope distribution,
VI: 197
wave length distribution,
VI: 202
wave height distribution,
VI: 205
wind generated, models of
VI: 205
transport theory, VI: 208
spectrum locus, I: 149
spherical harmonic method
III: 134
bases, III: 135
motivating argument, sum-
marized, III: 140
algebraic setting, III:
141
completeness property, III:
142, 153
abstract method, III: 143
finite abstract forms, III:
147, 149
classical method, general
media, III: 149

- spherical harmonic method
 --Cont'd.
 finite recurrence property, III: 154
 general differential equations, III: 157
 classical method, plane-parallel media, III: 158
 truncated solution procedure, III: 163
 spherical irradiance, II: 56
 VI: 278
 spherical medium (and scattering function), VI: 320
 spherical (point source) diffusion field, III: 200
 standard ellipsoid (for radiance distribution), V: 250
 standard growth and decay case (for n-ary radiant energy), IV: 87
 star product, IV: 45
 physical interpretation, IV: 46
 for invariant imbedding operators, IV: 54
 for , IV: 139
 static surface (and radiative transfer), VI: 34, 41, *et seq.*
 steradian, II: 38
 stochastic pressure model (of wave generation) VI: 207
 stochastic process, air water surface, VI: 115
 Stokes vector (for radiance), II: 88
 storage capacity (of an optical medium), III: 123
 stratified media, I: 62
 canonical equation for radiance, III: 18
 time-transformed principles of invariance, IV: 200
 submarine echoes (for spectra) VI: 180
 submarine light field, general representation, V: 93
 subsurface refractive phenomena, I: 33
 sun
 radiance of, II: 97
 radiant intensity of, II: 98
 luminance of, II: 164
 sun-based reference frame, II: 19
 supremum metric, III: 129
 surface interpretation of radiant flux, I: 12
 surface kinematic condition, VI: 55
 surface pressure condition, VI: 57
 surface waves, energy, VI: 72
 surfaces,
 solid angle subtense of, II: 112
 general two-sided, II: 267
 general one-sided, II: 271
 symbolic integration (term by term for natural solution), III: 65
 symmetric (optical medium), IV: 149
 talbot: II: 179
 telegrapher's equation, III: 185
 tensor diffusion equation, III: 184
 thermocline phenomena, I: 36
 time-averaged radiance fields, VI: 246
 hierarchy of, VI: 251
 time constant
 attenuation, III: 76
 scattering, III: 81
 absorption, III: 82
 dimensionless forms: III: 100
 for n-ary radiant energy, III: 109
 general discussion, III: 114
 time dependent equation of transfer, II: 371, IV: 18
 light field, III: 49
 n-ary radiant energy fields, III: 89
 operators, III: 68
 invariant imbedding relation, IV: 19
 principles of invariance, III: 23
 differential equations for R,T, IV: 25,26
 integral transfer method, IV: 194
 total scattering functions, V: 12
 transmission line equations, formal similarity with, V: 8
 transmittance for irradiance at air-water surface ($t = 1 - r$), I: 30

- transmittance--Cont'd.
 for finitely deep homogeneous water, I: 68
 complete (for irradiance) I: 79
 beam, I: 120
 contrast, I: 93
 empirical, for surfaces, II: 194
 operators, for surfaces, II: 210
 theoretical, for surfaces, II: 213
 lambert, II: 262
 algebra of operators, II: 230
 operators for plane-parallel media, II: 279
 semigroup properties, II: 300
 radiance, III: 14, 17
 local, IV: 3
 differential equations
 (undecomposed), IV: 2, 8
 (decomposed), IV: 16
 local residual, IV: 11
 local diffuse, IV: 12
 global diffuse, IV: 12
 causality condition, IV:
 time dependent differential equation, IV: 25, 26
 algebraic properties, IV: 27
 partition relation, IV: 29
 regularity properties, IV: 32
 asymptotic properties, IV: 33
 semigroup property, IV: 56, 106
 solution procedures, IV: 97, 83
 dual (complete), IV: 160
 for irradiance (undecomposed), V: 3
 for reduced and diffuse irradiance, V: 17
 in two-D model, V: 33, 35, 45
 complete (two-D), V: 62
 complete (one-D), V: 64
 differential equations, V: 65, 79
 for radiance, V: 164
 of static water surface (fresnel), VI: 3, 15
 operational determination (radiance), VI: 337
 transpectral scatter, III: 5
- transport (transfer) equations
 residual, radiant energy, III: 76
 n-ary radiant energy, III: 80
 directly observable radiant energy, III: 81
 for ocean wave spectra, VI: 208
 tristimulus functions, I: 144
 true absorption, III: 5
 truncation error estimates, II: 250
 truncated natural solution, III: 45
 time dependent, III: 69
 truncated spherical harmonic method, III: 163
 two-D models for irradiance fields, V: 25
 for undecomposed fields, V: 30
 first standard solution, V: 31
 second standard solution, V: 34
 for internal sources, V: 37
 for decomposed fields, V: 43
 inadequacies, V: 115
 eventual exactness, V: 247
 two-flow equations (for irradiance), V: 6
 undecomposed form, V: 8
 decomposed form, V: 14
 equilibrium form, V: 13
 ontogeny, V: 13
 for reduced irradiance, V: 17
 two-D (undecomposed) model, V: 30
 standard solutions, V: 31-34
 complete (general) solution, V: 42
 for decomposed irradiance, V: 43
 boundary conditions (effects), V: 46
 one-D (undecomposed) model, V: 52
 many-D models, V: 57
 exact vs. two-D, V: 115
 asymptotic behavior, V: 247
 two-flow (irradiance) model, I: 55, 56, 57
 two-path method (for beam transmittance), VI: 285

- unattenuated radiance, II: 347
 unified atmosphere-hydrosphere problem, II: 343
 unit source condition, III: 220
 universal radiative transport equation, V: 263
 for radiometric concepts, V: 263
 for apparent optical properties, V: 271
 and equilibrium principle, V: 279
 standard cases, V: 281
 additional cases, V: 281
 unpolarized-flux convention (in this work), I: 7
 unscattered radiance, III: 31
 equation of transfer, III: 37

 vector analogy with color, I: 146
 vector irradiance, III: 62
 via spherical harmonics, III: 177
 in classical diffusion theory, III: 198, 201, 207
 scattered form, III: 210
 n-ary, III: 217
 model for, in hydrosols, V: 87
 velocity (of a fluid packet) VI: 48
 velocity potential, VI: 54
 views of light (phenomenological vs. electromagnetic) II: 13
 visibility underwater, I: 154
 effect of depth and water clarity, I: 157
 use of nomographs, I: 163
 along inclined paths of sight, I: 165
 horizontal paths of sight, I: 170
 volterra prey-predator equations, I: 198
 volume absorption function, I: 60, III: 4
 measurement, I: 103
 operation of definition, I: 124, VI: 321
 volume attenuation function, I: 60
 operational definition, I: 119, VI: 290
 empirical, I: 120, II: 349
 for undecomposed light field, IV: 114

 volume backward scattering functions, I: 124
 volume forward scattering functions, I: 124
 volume scattering function, I: 122, II: 364
 σ -recovery procedures, VI: 312
 polarized, VI: 315
 volume total scattering function, I: 60, III: 4
 operational definition, I: 123, VI: 316
 volume transpectral scattering operator, II: 386

 Walsh's formula (for reflectance), VI: 18
 water clarity (visualization), I: 194
 watt, II: 171
 wave age, VI: 183
 wave diffusion equation, III: 185
 wave generation and decay, VI: 152
 wind speed connection, VI: 193
 wave height distribution, VI: 205
 wave slope data, VI: 132
 Hulbert's observations, VI: 136
 Duntley's observations, VI: 138
 intuitive gaussian picture, VI: 142
 wave slope-wind speeds law, VI: 145
 Cox and Munk's observations, VI: 145
 Schooley's observations, VI: 151, 155
 wave slope distribution (theoretical), VI: 197
 wave period (apparent), VI: 183
 wave-slope, wind-speed law derived, VI: 188
 wave spectrum data
 aerial stereo photography, VI: 166
 floating-buoy motion, VI: 173
 submarine echoes, VI: 180
 wave spectrum models (theoretical), VI: 194
 wave steepness, VI: 183

- wavelength distribution
(theoretical),
VI: 202
- wavelength, dominant,
I: 149
- waves, gravity and
capillary, VI: 71
superposition of,
VI: 76
- weighting functions
(for statistics of
air-water surface),
VI: 221
- white light, I: 149,
VI: 83
- Whitney's "general law" of
light field with depth,
V: 248
- Wiener-Khintchine theorem,
VI: 98
- Wien's displacement law
in oceanography,
VI: 186
- wind generated spectra,
models of, VI: 205
- wind profile (logarithmic),
VI: 132
- window (spectral), I: 134
- world region, III: 52