## SUBJECT INDEX

Acyclic auxiliary dynamical system	Cartesian coordinates, 234
kinetic equation of, 134	Catalytic cycle
kinetics of, 131–133	dynamic limitation in, 116
with one attractor, 133-135	ensembles of, 117–118
Arrhenius law, 118	inverse reaction in irreversible,
Asymptotic equivalence, of reaction network,	121–122
122	kinetic equation of, 115
Attractors	properties of, 114–115
acyclic auxiliary dynamical system,	relaxation equation for, 116–117
133–135	relaxation in subspace, 139
auxiliary discrete dynamical system,	static limitation in, 115–116
135–141	without limitation, 119
arbitrary family, 141–144	Chemical engineering, 181–182
Auxiliary discrete dynamical system, 130-131	Coefficients, of kinetic polynomial, 63–64
cycles surgery with arbitrary family of	Common curves, defined, 205
attractors for, 141–144	Common points, defined, 205
for chain and linear reaction network, 138	Complex kinetic models, rigorous analysis
with one attractor, 135–141	57–69
Auxiliary kinetics	Conditioning, paradoxes of, 125-126
distribution for, 136	Control coefficients, 107
eigenvectors for acyclic, 131-133	Convergence domain, 80-84
kinetic matrix of, 134	Curl, 219–224
relaxation approximation by, 135	curvilineal, 222
transformation, 136	spatial, 219–222
Auxiliary system, 149–154	surficial, 222
with one cyclic attractor, 141	Curvilineal curl, 222
Averaging theorems, 197, 199, 318–393, 408	vs spatial, 223
one macroscopic dimensions, 368–393	Curvilineal divergence, 216
curvilineal operator, 382–393	vs spatial, 216–217
spatial operator, 368–373	vs surficial, 217–218
surficial operator, 373–382	Curvilineal integration
three macroscopic dimensions, 319–342	of curvilineal operators, 311–316
curvilineal operator, 332–342	of spatial operators, 286–292
spatial operator, 319–323	of surficial operators, 295–305
surficial operator, 323–332	to point-value evaluation, 256–260
two macroscopic dimensions, 343–368	Curvilineal operators over a straight line,
curvilineal operator, 356–368	317–318
spatial operator, 344–348	Curvilineal operator theorems
surficial operator, 348–356	for one macroscopic, 382–393
	for three macroscopic, 332-342
Bezout root count, 64–65	for two macroscopic, 356-368
Bio-transport, 182–183	Curvilineal to surficial integral
Bloch's waves, 24	transformation, 253-256

Cycles gluing, 109–110, 136–153, 155–156, 164, 173	Energy budget equations scale-by-scale, 395, 398, 446
Cycles surgery	in turbulent flows, 394–398
for auxiliary discrete dynamical system,	Ensembles
141–144	of catalytic reaction, 117-118
branching of described algorithm for,	multiscale, reaction constant, 123-127
139–141	with well-separated reaction constants,
	118–119
Damkohler numbers, 2, 11	formal approach, 123
Derivation of the effective models	Entities, defined, 205
in non-dimensional form, 11-24	Equivalence with dual-phase-lagging heat
first order irreversible reaction, 22-24	conduction, 413–415
full linear model, 11–15	Ergodicity
infinite adsorption rate, 19–21	boundary reaction, 156–158
non-linear reactions, 15–19	relaxation of multiscale systems, 129–130
Derivatives, 209	
divergence, 213–219	Feasible roots, number of, 65
gradient, 212–213	Finite-additive distributions, reaction
orthonormal vectors, 210–212	constant, 123–127
vector functions, 212	First-order approximation, to steady states,
of unit vector, 227–228	145–146
Diagonal gap condition, 135	First order irreversible reaction, 22–24
Diffusivity, 4	Flux equation, 11 Fredholm's alternative, 11
Dirac delta function, 235	Freundlich's isotherm, 9
Discrete dynamical systems auxiliary. See Auxiliary discrete dynamical	Full linear model, with
systems	adsorption–desorption, 11–15
decomposition of, 130	1
Discretization in time, 25	Gershgorin discs, 169
Divergence, 213–219	Gershgorin theorem, 119
average theorem, 199	for estimation of eigenvectors, 168–170
curvilineal, 216	Gluing cycles
spatial, 213–215	auxiliary system, 149–150, 151, 152–153
surficial, 215–216	hierarchy of, 141-142
theorem, 202	prism of reactions, 144-146
Domain, defined, 203	Golay's theory, 11
Downscaling, 190	Gradient, 212–213
Dyadic del, of indicator functions,	of indicator function, 240-243
247–250	
Dynamic limitation	Hahn-Banach theorem, 124
catalytic cycle, 116	Hanging component, of reaction networks,
ergodicity boundary, 156–158	162
linear chain of reactions, 111–114	Heat conduction, in two-phase systems, 406–415
Eigenvalues	equivalence with dual-phase-lagging hea
auxiliary system, 150-151, 152, 153-154	conduction, 413-415
Gershgorin theorem for, 168–170	one- and two-equation models, 406-413
of matrix in catalytic cycle, 119	Heaviside function, 7, 228
Eigenvectors	Hierarchical spatial scale, 206
for acyclic auxiliary kinetics, 131–133	Hilbert–Schmidt expansion, 23
auxiliary system, 150–151, 152, 153–154	Horiuti–Boreskov problem, 55–57
estimation, diagonally dominant matrices,	Hydrogen electrode, 55
168–170 Eley-Rideal mechanism, 66	Hydrology, 180–181 Hypergeometric series 51, 71–73
Licy-Racai mechanism, 00	Hypergeometric series, 51, 71–73

Identities, indicator functions, 237–250	Interchange of integration dimensions,
of dyadic del, 247–250	252–260
of gradients, 240–243	curvilineal integration to point-value
integrands, 243–247	evaluation, 256–260
orthogonality relations, 237–240	curvilineal to surficial integral
time derivative, 243	transformation, 253–256
Indicator function	surficial to spatial integral transformation,
definitions, 228	252–253 Interfaces defined 204 205
derivatives, 228	Interfaces, defined, 204–205
of dyadic del, 247–250	Interior roots, number of, 65
of gradients, 240–243	Intermittent processes, 186
identities involving, 237–250	Inverse reaction, catalytic cycle with, 121–122 Irreversible fast first order reaction, 22–24
integration dimensions, 252–260	inteversible last first order reaction, 22–24
space curve, 230–232	Jacobian matrix mass action law 163
straight line, 228–230	Jacobian matrix, mass action law, 163
surface, 232–234 time derivative, 243	Vinctic equation
	Kinetic equation
volume, 234–236 Infinite adsorption rate 19–21, 40, 41	acyclic auxiliary dynamical system, 134
Infinite adsorption rate, 19–21, 40, 41, 42, 43	catalytic cycle, 115  Jacobian matrix for mass action law, 163
numerical experiment, 34–35	linear chain of reaction, 112
Integrands, with Del operator, 243–247	of linear reaction, 127
Integration and averaging theorems,	prism of reactions, 147
206–209	Kinetic polynomial, 50–51, 59–69
Integration theorems	coefficients, 63–64
over curves, 286–318	as generalized overall reaction rate
curvilineal integration of curvilineal	equation, 64–69
operators, 311–316	•
curvilineal integration of spatial	Langmuir-Hinshelwood mechanism, 66-69
operators, 286–292	Langmuir's isotherm, 8
curvilineal integration of surficial	Large eddy simulations (LES), 394
operators, 295–305	Law of mass action, 161
curvilineal operators over a straight line,	Jacobian matrix for, 163
317–318	Law of ordering, reaction constants, 126-127
spatial operators over a straight line, 292–295	Law of total probability, reaction constant, 126–127
surficial operators over a straight line,	Lebesgue measurable subset, 124
306–311	LES. See Large eddy simulations (LES)
over surfaces, 268–285	Lewis Carroll's obtuse problem, 125–126
spatial operators over a plane, 268–273	Limitation, in multiscale reaction networks
surficial integration of curvilineal	with comparable constants, 119–121
operators, 282–285	static. See Static limitation
surficial integration of spatial operators,	Linear chain, of reaction
279–282	kinetic equation for, 112
surficial integration of surficial	static and dynamic limitations in, 111–114
operators, 273–278	Linear conservation law, 127–128
surficial operators over a plane, 278–279	independent, 129
over volumes, 261–268	Linear curfoce adsorption description
spatial integration of curvilineal operators, 266–268	Linear surface adsorption—desorption reactions, 28
spatial integration of spatial operators,	Log-uniform distribution, of reaction rate
261–263	constant, 118
spatial integration of surficial operators,	Longitudinal transport time, 24
261–263	Lumping analysis, reaction kinetics, 159

Macroscale, 188	theorems, 202, 203
in balance equation, 200 defined, 206	integration and averaging theorems, 206–209
equations, of turbulence eddies,	systems and scales, 203-206
398–406	universe, 183–184
one-dimensional vortex filaments,	,
402–406	Non-dimensional form
three-dimensional spatial eddies,	derivation of the effective models, 11–24
398–400	effective equation, 6
two-dimensional surficial eddies,	of problem, 4–11
400–402	statement of the results, 4–11
interface equations, 419–429	Nonequilibrium phase transitions, in
averaging method, 423-429	multiscale reaction systems, 111, 155,
global balance method, 421-423	159–160
phase equations, 415–419	Non-linear reaction, 57–69
averaging method, 417	
global balance method, 417–419	non-linear mechanisms, 59–69
mixture theory of continuum mechanics,	coefficients, of kinetic polynomial, 63–64
416–417	cyclic characteristic and thermodynamic
MAL. See Mass-Action-Law (MAL)	consistency, 62–63
Mass-Action-Law (MAL), 52	resultant, in reaction rate, 59–61
Materials science and technology,	QSSA, 57–59
178–179	NOx emission, 182
Megascale, 188–189	Numerical experiments, of infinite
defined, 206	adsorption, 34–35
Mesoscale, 188	
Microscale, 188	Observation distance, 4
defined, 205	Observation scales, 187, 445
Mixture theory, 196	One-dimensional vortex filaments, 402–406
Model-downscaling, 200–203	One macroscopic dimensions, 368–393
Model-scaling, 192–203	curvilineal operator theorems, 382–393
model-downscaling, 200–203	spatial operator theorems, 368–373
model-upscaling, 192–200	surficial operator theorems, 373-382
Model-upscaling, 192–200	Orthogonality relations, 237–240
of macroscale balance equation, 200	Orthonormal vectors, 210–212
Modular limitation, 160–161	and properties, 210–212
Molecular scale, defined, 205	
Monotone relaxation, reaction systems of,	Péclet number, 2, 5
118–119	Periodic processes, 186
Multiscale	Perturbation analysis, and relaxation process,
bio-transport, 182–183	171–173
chemical engineering, 181–182	Phase transitions, nonequilibrium, 159–160
deviation theorems, 432–444	Phase volumes, defined, 204
for common curves, 441–444	Point microscale balance equation, 203
for interfaces, 437–443	Polyhedron, 124
for phase volumes, 434–437 hydrology, 180–181	Prism of reactions, 144–148
materials and science and technology,	kinetic equation, 147
178–179	rate constants, 144–145
modeling, 193, 201	Probability approach, to multiscale reaction
physics, 179–180	systems, 123–125
reaction networks	Process scales, 186, 444
nonequilibrium phase transitions in,	Pseudo-Steady-State Approximation (PSSA), 49
159–160	PSSA. See Pseudo-Steady-State
relaxation of, 127–130	Approximation (PSSA)
100	119910/411441011 (1 00/1)

QSSA. See Quasi-Steady-State Approximation (QSSA) Quasi-Steady-State Approximation (QSSA), 49, 57–59	Reversible triangle of reactions, 148–155 auxiliary system, 149–154 zero-one multiscale asymptotic for, 154–155
RAS. See Reynolds average simulations (RAS) Rate equation, for one-route linear mechanism, 52–54 Rate-limiting step equations, 51, 69–70 Reaction networks	Reynolds average simulations (RAS), 394 Reynolds number, 179 Root count, 64–65 Bezout root count, 64–65 number of feasible roots, 65 number of interior roots, 65
approximation by auxiliary kinetics, 135 asymptotic equivalence of, 122 hanging component of, 162 linear, 127–128 multiscale. <i>See</i> Multiscale reaction networks	Scale-by-scale energy budget equations, 446 Scales. <i>See also</i> specific scales Scaling, 189–192 Single polynomial, 50 Single route overall rate equation, 54–55 Sink
Reaction rate approximations, 69–86 classic, 69–71 overall reaction rate, 71–86	reaction network, 135–136 relaxation of multiscale reaction systems, 129–130 Slopelimit, 26
catalytic cycle, static limitation, 115–116 log-uniform distribution of, 118 prism of reactions, 144–145 relaxation spectroscopy for, 117 renormalization, 136	Solvable reaction mechanisms, 161–163 Space curve, 230–232 discretization, 25–28
standard deviation of, 118 Relaxation analysis, 111, 130–141 results of, 141–144 Relaxation equation, for catalytic cycle rate,	Spatial curl, 219–222 vs curvilineal, 223 Spatial divergence, 213–215 vs curvilineal, 216–217
116–117 Relaxation modes, zero-one law for, 159 Relaxation process approximation of, 114 kinetic system for approximation of, 143–144 mass transfer stage of, 110	vs surficial and curvilineal, 217 Spatial integration of curvilineal operators, 266–268 of spatial operators, 261–263 of surficial operators, 263–266 Spatial operator over a plane, 268–273
perturbation analysis and, 171–173 prism of action and analysis of, 148 Relaxation spectroscopy, for chemical reaction constant, 117	over a straight line, 292–295 theorems for one macroscopic dimensions, 368–373
Relaxation time of catalytic cycle without limitation, 119	for three macroscopic dimensions, 319–323 for two macroscopic dimensions, 344–348
reaction limitation with comparable constants, 120 robustness of, 117–118 of stable linear system, 116	Static limitation catalytic cycle, 115–116 linear chain of reactions, 111–114 Stationary rate, of catalytic cycle, 115, 116
Renormalization, reaction rate constant, 136 Representative elementary volume (REV), 196, 198, 207, 318	Steady-state reaction rate, 120 Steady states auxiliary system, 150, 151, 153
REV. See Representative elementary volume (REV)	first-order approximation, 145–146 reconstruction of, 142–143

zero-one law, 155 zero-order approximation, 143, 145, 147 Stochastic processes, 186 Stoichiometric vectors kinetic equation of linear reaction, 127 solvable reaction mechanisms, 161–162 Straight line, 228–230 Surface, 232–234 reactions, 8 solute concentrations, 9 Surficial curl, 222 formula of, 223–224 Surficial divergence, 215–216 vs curvilineal, 218–219 Surficial integration of curvilineal operators, 279–282 of surficial operators over a plane, 278–279 over a straight line, 306–311 theorem for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 343–336 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206 Taylor's dispersion coefficient, 3 Taylor's dispersion	of weakly ergodic reaction networks,	Time average theorem, 199
zero-order approximation, 143, 145, 147 Stochastic processes, 186 Stoichiometric vectors kinetic equation of linear reaction, 127 solvable reaction mechanisms, 161–162 Straight line, 228–230 Surface, 232–234 reactions, 8 solute concentrations, 9 Surficial divergence, 215–216 vs curvilineal, 218–219 Surficial divergence, 215–216 vs curvilineal operators, 279–282 of surficial operators, 279–282 of surficial operators, 279–282 of surficial operators, 273–278 Surficial operator, 273–278 Sur		
Stochastic processes, 186 Stochiometric vectors kinetic equation of linear reaction, 127 solvable reaction mechanisms, 161–162 Straight line, 228–230 Surface, 232–234 reactions, 8 solute concentrations, 9 Surficial curl, 222 formula of, 223–224 Surficial divergence, 215–216 vs curvilineal, 218–219 Surficial integration of curvilineal operators, 282–285 of spatial operators, 273–278 Surficial operator over a plane, 278–279 over a straight line, 306–311 theorem of or one macroscopic dimensions, 373–382 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206 Taylor's dispersion coefficient, 3 Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 spatial operator theorems, 319–323 sport modern and selection of indicator function, 243 in space, 225–226 Transport phenomena defining, 393–394 energy budget equations, 394–398 heat conduction, 406–415 macroscale equations, of turbulence eddies, 398–406 macroscale equations, 419–429 macroscale equatio	zero-order approximation, 143, 145, 147	
Stoichiometric vectors kinetic equation of linear reaction, 127 solvable reaction mechanisms, 161–162 Straight line, 228–230 Surface, 232–234 reactions, 8 solute concentrations, 9 Surficial curl, 222 formula of, 223–224 Surficial divergence, 215–216 vs curvilineal, 218–219 Surficial integration of curvilineal operators, 279–282 of surficial operators, 279–282 of surficial operators, 273–278 Surficial operators, 273–278 Surficial operators over a plane, 278–279 over a straight line, 306–311 theorem for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206 Taylor's dispersion coefficient, 3 Taylor's effective model, 3 Taylor's effective model, 3 Taylor's dispersion coefficient, 3 Taylor's effective model, 3 Taylor's effective model, 3 Taylor's effective model, 3 Taylor's effective model, 3 Taylor's dispersion coefficient, 3 Toro-dimensional surficial eddies, 400–412 Two macroscale equations, 415–419 macroscale equ		e e e e e e e e e e e e e e e e e e e
kinetic equation of linear reaction, 127 solvable reaction mechanisms, 161–162 Straight line, 228–230 Surface, 232–234 reactions, 8 solute concentrations, 9 Surficial curl, 222 formula of, 223–224 Surficial divergence, 215–216 vs curvilineal, 218–219 Surficial integration of curvilineal operators, 279–282 of spatial operators, 279–282 of spatial operators, 279–282 of surficial operators, 279–285 Surficial operators, 278–278 Surficial operator over a plane, 278–279 over a straight line, 306–311 theorem for one macroscopic dimensions, 373–382 for two macroscopic dimensions, 323–332 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206  Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamic ally constrained averaging theory (TCAT) Thermodynamic consistency, 62–63 Thermodynamic consistency, 62–63 Thermodynamic operator theorems, 319–342 spatial operator theorems, 319–322 spatial operator theorems, 319–323 on surface, 225–226 Transport phenomena defining, 393–394 energy budget equations, 394–398 heat conduction, 406–415 macroscale equations, of curbulence eddies, 398–406 macroscale equations, of turbulence eddies, 398–402 Transport phenomena defining, 393–394 energy budget equations, of common curves, 429–432 macroscale equations, of turbulence eddies, 398–406 macroscale equations, of turbulence eddies, 398–406 macroscale equations, of curbulence eddies, 398–402 Transport theorems, 319–342 to macroscale equations, of curbulence eddies, 398–402 Transport theorems, 32–342 to macroscale equations, of curbulence eddies, 398–402 Transport phenomena defining, 393–394 energy budget equations, of curbulence eddies, 398–402 Transport phenomena defining, 393–394 teregy budget equations, of curbulence eddies, 398–402 Transport phenomena defining, 393–406 macroscale equations, of curbulence e	Stoichiometric vectors	
solvable reaction mechanisms, 161–162 Straight line, 228–230 Surface, 232–234 reactions, 8 solute concentrations, 9 Surficial curl, 222 formula of, 223–224 Surficial divergence, 215–216 vs curvilineal, 218–219 Surficial operators, 279–282 of spatial operators, 279–288 Surficial operator over a plane, 278–279 over a straight line, 306–311 theorem for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 323–332 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206 Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic consistency, 62–63 Thermodynamic consistency, 62–63 Thermodynamic consistency, 62–63 Thermodynamic operator theorems, 319–342 spatial operator theorems, 319–342 spatial operator theorems, 319–323  Transport phenomena defining, 393–394 energy budget equations, 394–398 heat conduction, 406–415 macroscale equations, of common curves, 429–432 macroscale equations, of curbulence eddies, 398–406 macroscale equations, of curbulence eddies, 398–406 macroscale equations, of curbulence eddies, 398–406 macroscale equations, of turbulence eddies, 398–406 macroscale equations, of common curves, 429–432 macroscale equations, of curbulence eddies, 398–406 macroscale equations, 419–429 macroscale equations, 419–429 macroscale equations, 419–429 macroscop	kinetic equation of linear reaction, 127	•
straight line, 228–230 Surface, 232–234 reactions, 8 solute concentrations, 9 Surficial curl, 222 formula of, 223–224 Surficial divergence, 215–216 vs curvilineal, 218–219 Surficial integration of curvilineal operators, 273–278 Surficial operators, 273–278 Surficial operator over a plane, 278–279 over a straight line, 306–311 theorem for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 323–332 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206 Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic genilabrium, 70–71 There-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 spatial operator theorems, 319–322 spatial operator theorems, 319–323 spatial operator theorems, 348–356 urrilineal operator theorems, 348–356 spatial operator theorems, 348–356 spatial operator, 225–253 Turbulent mixing, 3 Tu		
solute concentrations, 9 Surficial curl, 222 formula of, 223–224 Surficial divergence, 215–216 vs curvilineal, 218–219 Surficial integration of curvilineal operators, 282–285 of spatial operators, 273–278 Surficial operators over a plane, 278–279 over a straight line, 306–311 theorem for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 323–332 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206  Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic equilibrium, 70–71 There-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 319–323 energy budget equations, 394–398 heat conduction, 406–415 macroscale equations, of turbulence eddies, 398–406 macroscale planes equations, 419–429 macroscale planes equations, 419–429 macroscale planes equations, of turbulence eddies, 398–406 macroscale planes interface equations, 419–429 macroscale equations, of turbulence eddies, 398–406 macroscale interface equations, 419–429 macroscale planes (quations, of turbulence eddies, 398–406 macroscale interface equations, 419–429 macroscale equations, of turbulence eddies, 398–406 macroscale interface equations, 419–429 macroscale equations, of turbulence eddies, 398–406 macroscale equations, of turbulence eddies, 398–406 macroscale interface equations, 419–429 multiscale deviation theorems, 342–444 Transport theorem, 202 Transversal diffusive time, 24 Tumor cells, 183 Turbulent mixing, 3 Two-dimensional surficial eddies, 400–402 Two macroscopic dimensions, 348–356 Universe, 183–184 Upscaling, 190  Vectors function, 106–415 macroscale equations, of turbulence eddies, 398–406 macroscale equations, of turbulent macroscale interface equations, 419–429 macroscale equations, 91 energy budget equations, 912 fase consultation, 106–415 macroscale equations, 912 fase consultation, 106–415 macroscale equations, 912 fase	Straight line, 228–230	
heat conduction, 406–415 macroscale equations, of common curves, 429–432 macroscale equations, of turbulence eddies, 398–406 macroscale interface equations, 419–429 macroscale phase equations, 419–429 macroscale interface equations, 419–429 macroscale equations, of turbulence eddies, 398–406 macroscale interface equations, 419–429 macroscale equations, of turbulence eddies, 398–406 macroscale interface equations, 419–429 macroscale interface equations, 419–429 macroscale equations, of turbulence eddies, 398–406 macroscale interface equations, 419–429 macroscale equations, of turbulence eddies, 398–406 macroscale equations, of turbulence eddie	Surface, 232–234	
solute concentrations, 9 Surficial curl, 222 formula of, 223–224 Surficial divergence, 215–216 vs curvilineal, 218–219 Surficial integration of curvilineal operators, 282–285 of spatial operators, 273–278 Surficial operator over a plane, 278–279 over a straight line, 306–311 theorem for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 323–332 for two macroscopic dimensions, 323–332 for two macroscopic dimensions, 328–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206  Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic equilibrium, 70–71 There-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 spatial operator theorems, 319–323  macroscale equations, of turbulence eddies, 398–406 macroscale interface equations, 415–419 multiscale deviation theorems, 422–444 Transport theorem, 202 Transversal diffusive time, 24 Tumor cells, 183 Turbulent mixing, 3 Two-dimensional surficial eddies, 400–402 Two macroscopic dimensions, 318–36 curvilineal operator theorems, 344–348 surficial operator theorems, 344–356  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155	reactions, 8	
formula of, 223–224 Surficial divergence, 215–216 vs curvilineal, 218–219 Surficial integration of curvilineal operators, 282–285 of spatial operators, 279–282 of surficial operator over a plane, 278–279 over a straight line, 306–311 theorem for one macroscopic dimensions, 323–332 for three macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206  Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic consistency, 62–63 Thermodynamic consistency, 62–63 There-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 332–342 spatial operator theorems, 319–323  429–432 macroscale equations, of turbulence eddies, 398–406 macroscale interface equations, 419–429 macroscale phase equations, 415–419 multiscale deviation theorems, 202 Transversal diffusive time, 24 Tumor cells, 183 Turbulent mixing, 3 Two-dimensional surficial eddies, 400–402 Two macroscopic dimensions, 343–368 curvilineal operator theorems, 348–356  Universe, 183–184 Upscaling, 190  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155	solute concentrations, 9	
formula of, 223–224 Surficial divergence, 215–216 vs curvilineal, 218–219 Surficial integration of curvilineal operators, 282–285 of spatial operators, 279–282 of surficial operators, 273–278 Surficial operator over a plane, 278–279 over a straight line, 306–311 theorem for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 323–332 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206 Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 319–323  macroscale equations, of turbulence eddies, 398–406 macroscale phase equations, 415–419 multiscale deviation theorems, 432–444 Transport theorem, 202 Transversal diffusive time, 24 Tumor cells, 183 Turbulent mixing, 3 Two-dimensional surficial eddies, 400–402 Two macroscopic dimensions, 348–356  Universe, 183–184 Upscaling, 190  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155	Surficial curl, 222	•
eddies, 398–406 macroscale interface equations, 419–429 macroscale interface equations, 419–429 macroscale interface equations, 419–429 macroscale phase equations, 415–419 multiscale deviation theorems, 432–444 Transport theorem, 202 Transversal diffusive time, 24 Tumor cells, 183 Turbulent mixing, 3 Two-dimensional surficial eddies, 400–402 Two macroscopic dimensions, 373–382 for three macroscopic dimensions, 323–332 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206 Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–406 Three macroscopic dimensions, 319–322  eddies, 398–406 macroscale interface equations, 419–429 multiscale deviation theorems, 432–444 Transport theorem, 202 Transversal diffusive time, 24 Tumor cells, 183 Turbulent mixing, 3 Two-dimensional surficial eddies, 400–402 Two macroscopic dimensions, 348–356  Universe, 183–184 Upscaling, 190  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155	formula of, 223–224	
vs curvilineal operators (282–285 of spatial operators, 279–282 of surficial operators, 279–282 of surficial operator over a plane, 278–279 over a straight line, 306–311 theorem for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 323–332 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206  Taylor's dispersion coefficient, 3 Taylor's dispersion coefficient, 3 Taylor's defective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–322 spatial operator theorems, 319–323  macroscale interface equations, 415–419 multiscale deviation theorems, 432–444  Transport theorem, 202 Transversal diffusive time, 24 Tumor cells, 183 Turbulent mixing, 3 Two-dimensional surficial eddies, 400–402 Two macroscopic dimensions, 343–368 curvilineal operator theorems, 344–348 surficial operator theorems, 348–356  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155	Surficial divergence, 215–216	
of curvilineal operators, 282–285 of spatial operators, 279–282 of surficial operators, 273–278 Surficial operator over a plane, 278–279 over a straight line, 306–311 theorem for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 323–332 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206 Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic consistency, 62–63 Thermodynamic consistency, 62–63 There macroscopic dimensions, 319–342 curvilineal operators, 279–282 multiscale deviation theorems, 432–444 Transport theorem, 202 Transversal diffusive time, 24 Tumor cells, 183 Turbulent mixing, 3 Two-dimensional surficial eddies, 400–402 Two macroscopic dimensions, 348–368 curvilineal operator theorems, 344–348 surficial operator theorems, 348–356  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155	vs curvilineal, 218–219	
of spatial operators, 279–282 of surficial operators, 279–282 of surficial operator, 273–278 Surficial operator over a plane, 278–279 over a straight line, 306–311 theorem for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 348–356 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206 Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–322  multiscale deviation theorems, 432–444 Transport theorem, 202 Transversal diffusive time, 24 Tumor cells, 183 Turbulent mixing, 3 Two-dimensional surficial eddies, 400–402 Two macroscopic dimensions, 344–348 surficial operator theorems, 344–348 surficial operator theorems, 348–356  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155	Surficial integration	
of surficial operators, 273–278 Surficial operator over a plane, 278–279 over a straight line, 306–311 theorem for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 328–332 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206 Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 323–332 Systems and scales, 203–206 Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 332–342 spatial operator theorem, 202 Transversal diffusive time, 24 Tumor cells, 183 Turbulent mixing, 3 Two-dimensional surficial eddies, 400–402 Two macroscopic dimensions, 343–368 curvilineal operator theorems, 348–356  Universe, 183–184 Upscaling, 190  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		
Surficial operator over a plane, 278–279 over a straight line, 306–311 theorem for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 323–332 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206  Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 323–382  Universe, 183 Turbulent mixing, 3 Two-dimensional surficial eddies, 400–402 Two macroscopic dimensions, 343–368 curvilineal operator theorems, 344–348 surficial operator theorems, 348–356  Universe, 183 Turbulent mixing, 3 Two-dimensional surficial eddies, 400–402 Two macroscopic dimensions, 348–368 curvilineal operator theorems, 348–356  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		
over a plane, 278–279 over a straight line, 306–311 theorem for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 323–332 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206  Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Theredynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 343–368 curvilineal operator theorems, 344–348 surficial operator theorems, 344–348 surficial operator theorems, 348–356  Universe, 183 Turbulent mixing, 3 Two-dimensional surficial eddies, 400–402 Two macroscopic dimensions, 343–368 curvilineal operator theorems, 343–368 curvilineal operator theorems, 344–348 surficial operator theorems, 348–356  Universe, 183 Turbulent mixing, 3 Two-dimensional surficial eddies, 400–402 Two macroscopic dimensions, 343–368 curvilineal operator theorems, 344–348 surficial operator theorems, 344–348 Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		*
over a straight line, 306–311 theorem for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 323–332 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206  Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 343–368 curvilineal operator theorems, 344–348 surficial operator theorems, 348–356  Universe, 183–184 Upscaling, 190  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		
theorem for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 323–332 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206 Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional surficial eddies, 400–402 Two macroscopic dimensions, 343–368 curvilineal operator theorems, 344–348 surficial operator theorems, 348–356  Universe, 183–184 Upscaling, 190  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		
for one macroscopic dimensions, 373–382 for three macroscopic dimensions, 323–332 for two macroscopic dimensions, 348–356 for two macroscopic dimensions, 348–356  Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206  Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 343–368 curvilineal operator theorems, 344–348 surficial operator theorems, 348–356  Universe, 183–184 Upscaling, 190  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155	_	
for three macroscopic dimensions, 323–332 for two macroscopic dimensions, 348–356  Surficial to spatial integral transformation, 252–253  Systems and scales, 203–206  Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT)  Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 319–323  curvilineal operator theorems, 356–368 spatial operator theorems, 344–348 surficial operator theorems, 348–356  Universe, 183–184 Upscaling, 190  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		
for three macroscopic dimensions, 323–332 for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206 Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 344–348 surficial operator theorems, 348–356  Universe, 183–184 Upscaling, 190  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		
for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206  Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 332–342 spatial operator theorems, 319–323  surficial operator theorems, 348–356  Universe, 183–184 Upscaling, 190  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		
for two macroscopic dimensions, 348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206  Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 332–342 spatial operator theorems, 319–323  Universe, 183–184 Upscaling, 190  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		
348–356 Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206  Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 332–342 spatial operator theorems, 319–323  Universe, 183–184 Upscaling, 190  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		surficial operator theorems, 348–356
Surficial to spatial integral transformation, 252–253 Systems and scales, 203–206  Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 332–342 spatial operator theorems, 319–323  Upscaling, 190  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		
252–253 Systems and scales, 203–206  Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 332–342 spatial operator theorems, 319–323  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		Universe, 183–184
Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 332–342 spatial operator theorems, 319–323  Vectors functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		Upscaling, 190
Taylor's dispersion coefficient, 3 Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 332–342 spatial operator theorems, 319–323  functions, 212 stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155	Systems and scales, 203–206	Vactors
Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 332–342 spatial operator theorems, 319–323  stoichiometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		
Taylor's effective model, 3 TCAT. See Thermodynamically constrained averaging theory (TCAT) Thermodynamically constrained averaging theory (TCAT) Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 332–342 spatial operator theorems, 319–323  Stolcthometric, 127 Velocity, 4 Volume, 234–236  Zero-one law, 155–159 dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155	Taylor's dispersion coefficient, 3	
TCAT. See Thermodynamically constrained averaging theory (TCAT)  Thermodynamically constrained averaging theory (TCAT)  Thermodynamic branch, 50, 78–80  Thermodynamic consistency, 62–63  Thermodynamic equilibrium, 70–71  Three-dimensional spatial eddies, 398–400  Three macroscopic dimensions, 319–342     curvilineal operator theorems, 332–342     spatial operator theorems, 319–323  Velotity, 4  Volume, 234–236  Zero-one law, 155–159     dynamic limitation and ergodicity boundary, 156–158     for nonergodic multiscale networks, 155–156     for relaxation modes, 159     for steady states of weakly ergodic reaction networks, 155	Taylor's effective model, 3	
averaging theory (TCAT)  Thermodynamically constrained averaging theory (TCAT)  Thermodynamic branch, 50, 78–80  Thermodynamic consistency, 62–63  Thermodynamic equilibrium, 70–71  Three-dimensional spatial eddies, 398–400  Three macroscopic dimensions, 319–342     curvilineal operator theorems, 332–342     spatial operator theorems, 319–323  Volume, 234–236  Zero-one law, 155–159     dynamic limitation and ergodicity boundary, 156–158     for nonergodic multiscale networks, 155–156     for relaxation modes, 159     for steady states of weakly ergodic reaction networks, 155		
theory (TCAT)  Zero-one law, 155–159  dynamic limitation and ergodicity boundary, 156–158  for nonergodic multiscale networks, 155–156  for relaxation modes, 159  curvilineal operator theorems, 332–342 spatial operator theorems, 319–323  Zero-one law, 155–159  dynamic limitation and ergodicity boundary, 156–158  for nonergodic multiscale networks, 155–156  for relaxation modes, 159  for steady states of weakly ergodic reaction networks, 155		volume, 234–236
Thermodynamic branch, 50, 78–80 Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 332–342 spatial operator theorems, 319–323  dynamic limitation and ergodicity boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155	Thermodynamically constrained averaging	Zero-one law. 155–159
Thermodynamic consistency, 62–63 Thermodynamic equilibrium, 70–71 Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 332–342 spatial operator theorems, 319–323 boundary, 156–158 for nonergodic multiscale networks, 155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		
Thermodynamic equilibrium, 70–71 for nonergodic multiscale networks,  155–156 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 332–342 spatial operator theorems, 319–323 for steady states of weakly ergodic reaction networks, 155		
Three-dimensional spatial eddies, 398–400 Three macroscopic dimensions, 319–342 curvilineal operator theorems, 332–342 spatial operator theorems, 319–323  155–156 for relaxation modes, 159 for steady states of weakly ergodic reaction networks, 155		
Three macroscopic dimensions, 319–342 for relaxation modes, 159 curvilineal operator theorems, 332–342 spatial operator theorems, 319–323 for steady states of weakly ergodic reaction networks, 155		
curvilineal operator theorems, 332–342 for steady states of weakly ergodic reaction networks, 155		
spatial operator theorems, 319–323 networks, 155		
1		
	, , , , , , , , , , , , , , , , , , , ,	, , , , , , , , , , , , , , , , , , , ,