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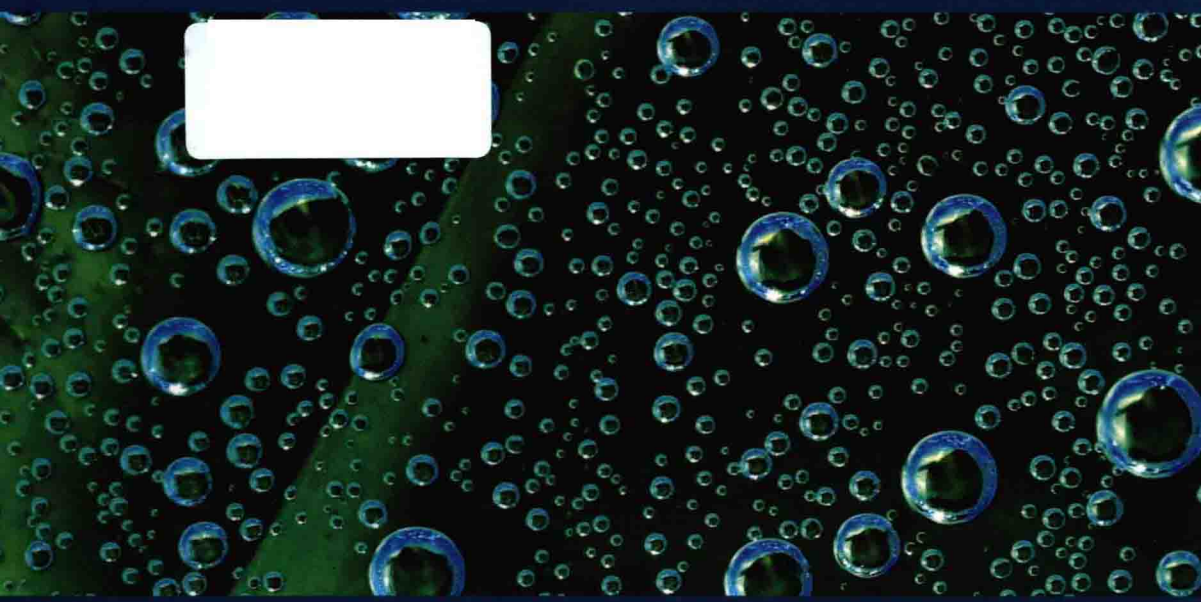

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List of Main Symbols

Latin characters

a	surface strain rate
a, b	partial derivatives of pressure with respect to ξ and A respectively
A	chemical affinity; chemical species; or monatomic species
A_2	diatomic species
$\underline{\mathrm{A}}$	column matrix of chemical affinities in a multi-reactive medium
A, B	Arrhenius coefficients
c	speed of sound; or molecular speed
c_K	characteristic celerity in a multi-reactive mixture
$c_1, c_\mu, c_\varepsilon, c_k$	coefficients of the $k-\varepsilon$ method
C	total number of moles per unit volume; or Germano's parameter
C_f	friction coefficient
C_j	molar concentration per unit volume

C_p, C_v	specific heat at constant pressure or constant volume respectively (c_p, c_v for the unit of mass)
Cr	crispation number
d	molecular diameter; distance; or differential
D	diffusion coefficient; or diameter
$\vec{\vec{\mathrm{D}}}$	strain rate tensor
Da	Damköhler number
D_T	thermal diffusion coefficient
D_T, D_p	partial derivatives of $\ln n$ with respect to $\ln T$ and $\ln p$ respectively
e	roughness thickness
$\vec{\mathrm{e}}_i$	orthonormal basis vector
E	internal energy (e per unit mass)
$E(t_e)$	residence time distribution in a chemical reactor
$E(k)$	energy spectrum of turbulence
E_a	activation energy
$\mathcal{E}, \mathcal{E}_j$	chemical species
f	parameter; or reduced chemical production rate
f', f''	Reynolds, Favre fluctuation, respectively
$\vec{f}$	force acting on each unit mass
$\vec{f}_j$	force acting on the unitary mass of the species j

F	Helmholtz free energy (f for the unit of mass); generalized force; or any extensive value (f for the unit of mass)
$\vec{\mathrm{F}}$	force
G	Gibbs free enthalpy (g for the unit of mass); or production rate of entities per unit volume of the phase space
$G(\vec{\mathrm{x}},t)$	filter in the physical space
$G(\vec{\mathrm{k}},\omega)$	filter in the Fourier space
$\vec{\mathrm{g}}$	acceleration due to gravity (of modulus g)
g_j	chemical potential per unit mass of the species j in a mixture
H	enthalpy (h per unit mass)
h_0	stagnation enthalpy
$\vec{\vec{1}}$	unit tensor
$I(\alpha)$	distribution of ages
j	chemical species
$\vec{J}_{Dj}$	diffusion flux of the species j
J_0, J_1	Bessel functions
k	Boltzmann's constant; wave number; or kinetic energy of turbulence
$k(T)$	specific reaction rate
K	kinetic energy (k per unit mass); compressibility; number of chemical reactions in a mixture; heat exchange coefficient; or wave number

K_F	turbulent exchange coefficient for the quantity F
K_C, K_p	equilibrium constants for the concentrations and the partial pressures, respectively
l	latent heat per unit mass; or mean free path
ℓ	length of transfer; or integral scale of turbulence
L	length; molar latent heat; number of chemical elements in a mixture; size of a crystal; or phenomenological coefficient of a chemical reaction
ℓ_D	diffusion thickness of a non premixed flame
ℓ_f, ℓ_δ	thickness of preheating, of reaction of a premixed flame, respectively ℓ_G, ℓ_K: length scales of Gibson, of Kolmogorov, respectively
Le	Lewis number
Lp	Prandtl mixing length
$\underline{\underline{\mathrm{L}}}$	matrix of phenomenological coefficients of chemical reactions
$\mathcal{L}$	resolved strained tensor (in LES)
$\mathcal{L}(f)$	derivation operator in cylindrical coordinates
m	total mass
M	molecular mass; diluent; or Mach number
$\mathcal{M}$	molar mass
m_j	mass of the species j
$\mathcal{M}_j$	molar mass of the species j
$\dot{m}$	unit mass flow rate; or mass flow rate of a nozzle

n	total number of moles
n_j	number of moles of the species j
N	number of species; number of molecules per unit volume; or coordinate normal to an interface
$\vec{\mathrm{n}}, \vec{\mathrm{N}}$	unitary normal to an interface
p	thermodynamic pressure
P	probability density
$\vec{\vec{\mathrm{P}}}$	pressure tensor
Pr	Prandtl number
q	any parameter; or heat flux
$\dot{q}$	volume flowrate
$\vec{\mathrm{q}}$	heat flux vector
Q	partition function; or quantity of heat
$\dot{Q}$	heat released per unit time at the walls of a chemical reactor
$\left(Q_f^0\right)_j = \left(H_0^0\right)_j$	molar enthalpy of formation of the species j ($\left(q_f^0\right)_j$ per unit mass)
r	constant of perfect gases per unit mass; radius; or caloric power received per unit volume
R	universal molar gas constant; radius; or number of independent chemical species in a mixture
$R(\xi)$	correlation coefficient
Re	Reynolds number

R_j	mass production of species j by chemical reaction
s	Arrhenius exponent
S	entropy (s per unit mass); area of the cross-section of a nozzle
s_L, s_L^0, s_t	laminar combustion velocity, standard, and turbulent, respectively
S, $\mathcal{S}$	surface
S	symmetrical part of the velocity gradient tensor
Sc	Schmidt number
t	time; diffusion thickness
t_e	residence time in a chemical reactor
T	absolute temperature; or Chapmann-Jouguet detonation point
T_a, T_{ad}	activation temperature, adiabatic temperature of a reaction, respectively
$\bar{\bar{\mathrm{T}}}, \mathrm{T}$	double-filter tensor (in LES)
$\bar{\bar{\mathcal{T}}}, \mathcal{T}$	unresolved Reynolds tensor (in LES)
u, v, w	velocity $\vec{\mathrm{v}}$ components in Cartesian coordinates (v_{r}, v_θ, v_z in cylindrical coordinates)
U, U_∞	reference velocity
$\vec{\mathrm{U}}, \vec{\mathrm{v}}$	velocity vector; or barycentric velocity vector in a composite fluid
v, v'	speed, turbulence intensity respectively
V	speed; force; volume in the phase space; or potential

$\vec{\mathrm{V}}$	vector; velocity vector; or velocity vector in the phase space $\left(\vec{\mathrm{x}},\vec{\zeta}\right)$
$\mathcal{V}$	volume; or control volume
$\vec{\mathrm{v}}_j$	velocity vector of the species j
$\vec{\mathrm{V}}_j$	diffusion velocity of the species $\vec{\mathrm{v}}_j - \mathrm{v}$
$\vec{\mathrm{w}}$	velocity of a surface (normal component w); or $d\vec{\zeta}/dt$ in the phase space
$\vec{\mathrm{W}}$	local velocity vector of a discontinuity
$\dot{W}_F$	rate of production of the quantity F ($\dot{W}_j$ for species j)
$\dot{W}_{E\alpha,\mathrm{int}}$	rate of production of energy for the internal degrees of freedom of the species j
x, y, z	Cartesian coordinates; x along a nozzle axis
$\vec{\mathrm{x}}$	position vector
$\mathrm{X_j}$, $\mathrm{Y_j}$	molar and mass fraction of the species j respectively
Z	fraction of mixture

Greek symbols

α	species; or age of an entity in a chemical reactor
β_j, β_T	reduced concentration, respectively reduced temperature
δ	thickness of a viscous layer; $\delta(x)$: Dirac distribution
Δ	difference; Laplacian; size of a filter (in LES); ΔH: heat of a reaction

ε	small dimensionless parameter; or turbulent dissipation rate
ε_δ	relative roughness
φ	velocity potential; $\varphi(\bar{x},t)$: weight function
ϕ_j	partial molar quantity associated with the quantity ϕ
γ	isentropic coefficient c_p/c_v ; damping of a wave
Γ	circulation of a vortex; second partial derivative of enthalpy
χ	scalar local dissipation rate
η	partial bulk viscosity; or reduced coordinate
κ	thermal diffusivity $\lambda/\rho c_p$; or mean curvature of a surface
λ	coefficient of thermal conductivity; eigenvalue; Taylor's micro-scale
Λ	coefficient of head-loss; or heat transfer coefficient
μ	coefficient of shear viscosity; Gibbs free energy per mole; or absorption coefficient per unit of wave length
μ_j	molar chemical potential of a species j in a mixture
ν	kinematic viscosity μ/ρ
ν_t	turbulent kinematic viscosity
ν_j	algebraic stoichiometric coefficient $\nu_j = \nu''_j - \nu'_j$
ν'_j, ν''_j	stoichiometric coefficient of the direct reaction, or its inverse respectively
$\bar{\bar{\Pi}}$	viscous pressure tensor

Π_i	dimensionless group
θ	temperature; or angular coordinate
ϑ	volume per unit mass (inverse of the density)
ρ	density (volumetric mass)
ρ_j	partial density
σ	surface tension
Σ	surface; area of a surface; $\Sigma(x)$ area of the cross-section of a nozzle
$\vec{\vec{\Sigma}}$	stress tensor
$\sigma_k, \sigma_\varepsilon$	Prandtl numbers of the $k-\varepsilon$ method
τ	characteristic time; crossing time in a chemical reactor; dimensionless energy of reaction $\tau = \Delta H / c_p T_1$
ω	speed of rotation; or pulsation of an oscillating wave; function of β_T
$\vec{\omega}$	rotation vector
Ω	speed of rotation
$\vec{\Omega}$	rotation vector
ξ	progress variable per unit mass; reduced coordinate; or correlation length
$\underline{\xi}$	column matrix of the progress variables
ψ	stream function; or probability in the space phase
ζ	progress variable per unit volume; or reduced variable

$\dot{\zeta}$	rate of production of a chemical reaction
$\vec{\zeta}$	vector of the phase space

Subscripts, superscripts, and other symbols

a	of activation; or relative to the quantities per unit area of the interface
ad	adiabatic
b	burned gases
c	concentration; or cut-off
C	critical point
chem	chemical
$CO\text{-}E_{\beta v}$	coupling CO molecule - vibrational energy
d	relative to small dissipative eddies
D	direct; of dissociation; or diffusive
e	equilibrium flow; exit of a reactor; residence; or large eddies
eff	effective
EBU	relating to the "Eddy break-up" model
f	frozen composition; fresh gases; or flame
G , g	gas
α , β, i, j	of species
i	internal; relative to imaginary part; or irreversible

int	internal degrees of freedom of a molecule
K	for the K frozen progress variables
l	liquid
L	line; liquid; or laminar
m	mixture; mass
mec	mechanical
p	at constant pressure; or solid phase
q	extinction limit of a flame
r	chemical reaction; or reference
R	reverse; or recombination
$R-K$	relative to the $R-K$ progress variables at equilibrium
s	steady state; surface; or isentropic
o	entry of a reactor
S	surface; relative to the specific or intensive interfacial quantities
st	stoichiometric; or steady
t	for translational energy mode of a molecule; turbulent
T	temperature; turbulent; or at constant temperature
$\underline{\underline{T}}$	second order tensor; or transpose of a tensor
$^{\circ}$	deviator of a tensor
th	thermal

$_v$, or $_\vartheta$	at constant volume
$_V$	vapor
$_{//}$	parallel to a surface
$_\perp$	normal to a surface
$_0$	standard reference value
$_\bullet$	pure simple substance
$\dot{}$	per unit time; or for a rate of production
$\bar{}$	thermodynamic value per mole; average quantity; or Reynolds average
$'$	Reynolds disturbance in relation to an average value
$''$	Favre disturbance in relation to an average value
$S(\ )$	symmetrical part of a matrix or a tensor
$\tilde{}$	transposed tensor; transposed matrix; or Favre average
$\langle\ \rangle$	ensemble average
$\hat{}$	pre-exponential factor; or relative to a test filter in LES
$(\ )_T^0$	standard thermodynamic function
$\times$	vector product
$\otimes$	tensor product
$\cdot$	scalar product (singly-contracted tensor product)
$:$	dyadic product (doubly-contracted tensor product)
$\wedge$	exterior product