LIST OF SYMBOLS

a	particle radius (m)
a	weight function (–)
a_i	weight function for sum-of-gray-gases model (–)
A	area (m^2)
A	total band absorptance (–)
A^*	dimensionless band absorptance (= A/ω) (–)
$\overline{A}$	spectrum integrated absorptance (–)
A_{ij}, B_{ij}	Einstein probability coefficients (–)
b	line half-width (–)
B	rotational constant (–)
Bo	Boltzmann number (convection-to-radiation parameter) (–)
c	speed of light (m/s)
c_o	speed of light in vacuum (m/s)
C_1, C_2	Planck's first and second constants (see Table 2.1)
C_3	constant in Wien's displacement law (see Table 2.1)
C_f	molar fuel concentration (N/m^3)
d	line spacing (–)
d	particle diameter (m)
D	diameter (m)
$\mathfrak{D}$	binary diffusion coefficient (m^2/s)
E	emitted flux (W/m^2)
$\mathbf{E}$	electric field vector (N/C)
$\mathfrak{E}$	net (emission – absorption) volumetric radiant energy loss/gain (W/m^3)
E_b	blackbody emitted flux (W/m^2)
$E_n(x)$	exponential integral function (–)
f_v	volume fraction (–)
f_v	photon distribution function (–)
$\mathfrak{F}$	radiation flux vector (W/m^2)
$F_{0-\lambda T}$	fractional blackbody function (–)
F_{i-j}	configuration (view, angle) factor between finite area i and area j (–)
G	irradiation (incident radiation flux) on a surface (W/m^2)
$\mathfrak{G}$	irradiance (radiation incident on a volume of matter, from all possible directions) (W/m^2)
h	enthalpy (J/kg)
h	convective heat transfer coefficient (W/m^2K)
h	Planck's constant (= 6.626×10^{-34}Js)

$\mathbf{H}$	magnetic field vector (–)
ΔH_{fg}	latent heat of vaporization (J/kg)
$\mathbf{i}$	unit vector in the x-direction (–)
I	intensity of radiation (radiance) (W/m^2 · sr)
I_b	blackbody intensity of radiation (= $\sigma T^4/\pi$) (W/m^2 · sr)
$\mathbf{j}$	unit vector in the y-direction (–)
J	rotational quantum number (–)
J	radiosity (radiation flux leaving a surface) (W/m^2)
k	thermal conductivity (W/m K)
k	Boltzmann constant (= 1.3807×10^{-23} J/K)
k	imaginary part of complex index of refraction (–)
$\mathbf{k}$	unit vector in the z-direction (–)
l,m,n	direction cosines with x-, y-, z-axis (–)
L	length (m)
L_m	mean beam length (m)
L_o	geometric mean beam length (m)
m	mass flux (kg/m^{2}s)
m	complex index of refraction (–)
n	real part of complex index of refraction (–)
n	self-broadening exponent in Eq. (4.58) (–)
$\mathbf{n}$	unit vector normal to real or imaginary surface (–)
N	number of particles per unit volume (#/m^3)
Nu	Nusselt umber (–)
p	pressure (N/m^2)
$\mathcal{P}$	radiation pressure (N/m^2)
P_l	Legendre polynominals (–)
Pr	Prandtl number (–)
q	heat flux (W/m^2)
$\mathbf{q}$	heat flux vector (W/m^2)
Q	heat transfer rate (W)
Q	Mie efficiency factor (–)
r	radial coordinate (m)
$\mathbf{r}$	position vector (m)
R	radius (m)
$\mathcal{R}$	universal gas constant (= 8.3145J/mol K)
Re	Reynolds number (–)
s	distance measured along the direction of ray propagation (m)
$\mathbf{s}$	unit vector in the direction of ray propagation (–)
S	line-integrated absorption coefficient (line strength) (–)
S	source function (W/m^3)
S	distance between two points in the medium (m)
S	flame speed (m/s)
$\mathbf{S}$	Poynting vector (W/m^2)
St	Stanton number (–)
$\overline{S_iS_j}$, $\overline{S_iG_k}$	total exchange area in zone method (m^2)
t	time (s)
T	temperature (K)

u	internal energy (J/kg)
u	velocity in the x-direction (m/s)
u	scaling function for absorption coefficient (–)
U	overall heat transfer coefficient (W/m^2K)
$\mathcal{U}$	radiant energy density (J/m^3)
v	vibrational quantum number (–)
v	velocity in the y-direction (m/s)
$\mathbf{v}$	velocity vector (m/s)
V	volume (m^3)
w_i	quadrature weight (–)
W	equivalent line width (–)
W	molecular weight (–)
x,y,z	Cartesian coordinates (m)
X	optical length (–)
X_i	mole fraction of species i (–)
Y_l^m	spherical harmonics (–)
Y_i	mass fraction of species I (–)

Greek Symbols

α	absorptivity or absorptance (–)
α	band-integrated absorption coefficient (band strength parameter) (–)
α	thermal diffusivity ($= k/\rho c_p$) (m^2/s)
β	extinction coefficient ($= \kappa + \sigma$) (m^{-1})
β	line overlap (structure) parameter (–)
Γ	generalized diffusion coefficient (m^2/s)
δ	Dirac-delta function (–)
δ_{ij}	Kronecker delta function (–)
ε	emissivity or emittance (–)
ε	electrical permittivity of matter (C^2/Nm^2)
ε	complex dielectric function ($= \varepsilon' - \varepsilon''$) (–)
θ	polar angle (rad)
Θ	scattering angle (rad)
κ	absorption coefficient (m^{-1})
λ	wavelength (μm)
μ	dynamic viscosity (kg/ms)
μ	magnetic permeability (Ns^2/C^2)
μ	direction cosine ($= \cos\theta$) (–)
ν	frequency (Hz)
ν	kinematic viscosity (m^2/s)
ξ	direction cosine (–)
ξ	dimensionless coordinate (–)
ρ	reflectivity or reflectance (–)
ρ	density (kg/m^3)
σ	Stefan-Boltzmann constant ($= 5.670 \times 10^{-8} W/m^2\ K^4$)
σ	scattering coefficient (m^{-1})
τ	transmissivity (–)

τ	optical distance or optical coordinate (–)
Υ	transmittance (–)
ϕ	azimuthal angle (rad)
ϕ	porosity (–)
ϕ	general scalar variable (ρ, u, v, w, t_ρ, T, h,Y_i . . .)
Φ	scattering phase function (–)
ω	single scattering albedo (= σ/β) (–)
ω	wave number (1/cm)
ω	angular frequency (rad/s)
$\dot{\omega}_i$	mass rate production of species l (kg/m^{3}s)
Ω	solid angle (sr)
χ	particle size parameter (–)
χ_R	radiant fraction (–)

Subscripts

1,2	at location “1” or “2”
a	absorption
amb	ambient
av	average
b	blackbody
c	chemical
c	collimated or beam flux
C	collision or convection
d	diffuse flux or droplet
D	Doppler or based on diameter
e	effective
e	extinction
eff	effective
f	fuel or flame
g	gas
i	incident or dummy counter
j	rotational sate or dummy counter
k	absorption coefficient variable or dummy counter
ℓ	leaving
L	at length
mix	mixture
n	normal direction
o	reference value or in vacuum
p	particle
P	Planck-mean
r	reflected
R	reflected component or radiation
R	Rosseland-mean or at $r = R$
s	along the path s or at surface
s	solid or surroundings
s	scattering

t	transmitted component
u	upper limit
v	at a vibrational state or at constant volume
w	wall value
x,y,z	components in the x,y,z directions
θ,ϕ	in a given direction
λ	at a given wavelength or per unit of wavelength
ν	at a given frequency or per unit frequency
ω	at a given wave number or per unit wave number
$\|\|$	polarization component or situated in plane of incidence
$\perp$	polarization component or situated in plane perpendicular to the plane of incidence

Superscripts

o	external
$'$, $''$	real and imaginary parts of a complex number
$\cap$	hemisphere of solid angle
$+$, $-$	into “positive” and “negative” directions
d	diffusive
s	specular
$-$	average value or spectrum integrated
$\sim$	Favre average or effective