

List of Symbols

The mathematical symbols appearing infrequently or only in one section or a few pages are not included in this list. Such symbols are generally defined locally. The location of a symbol is given when it occurs for the first time either by the equation number or the page number or redefined in a slightly different context or equation.

Italic and Roman Symbols

a_{SB}	Stefan–Boltzmann constant	p. 110, 112
C_a	Nonrelativ. peculiar velocity	p. 17, 18, 19
\widehat{C}_{pa}	Constant p heat capacity/mass	p. 62, 63, 71, 72, 77
$C(f_a f_b)$	Boltzmann–Nordholm– Uehling–Uhlenbeck (BNUU) collision term	p. 102
$C_r(f_a f_b f_k^* f_l^*)$	BNUU radiation collision term	p. 102
$C_{ab}(f_a, f_b)$	Collision intergral	p. 4
D_{aj}^0, D_a^0	Diffusion coefficient	p. 66, 161
D_{aj}	Nonlinear diffusion coeff.	p. 163, 164
$D_{aj}^{(dh)0}$	Diffusive heat conductivity	p. 66
$D_{aj}^{(dh)}$	Nonlinear diff heat conductivity	p. 73
$D_{aj}^{(td)0}$	Thermal diffusivity	p. 66
$D_{aj}^{(td)}$	Nonlinear thermal diffusivity	p. 73
E_a	Energy eigenvalue of an atom	p. 100
$E, E_a,$	Scalar energy,	p. 9, 12, 119
$\mathcal{E}, \mathcal{E}_a$	Energy density	p. 9, 12, 37, 68, 112, 116, 127, 137, 153
\mathcal{E}^e	Equil. internal energy density	p. 106, 107, 108
\mathcal{E}_r^e	Radiation energy density	p. 110, 112

F_L^μ	Lorentz force	p. 31
f_a	Distribution function	p. 3, 101, 170
$f_a^e(p_a)$	Equilibrium distribution function	p. 30, 32, 33, 35, 105, 179
f_r^e	Equil. radiation distribution func.	p. 109, 110, 179
f_a^c	Nonequil. canonical form of f_a	p. 40, 41, 53, 133
$f_c^{(N)}$	Nonequil. canonical form of an ensemble	p. 41
f_r^c	Nonequil. radiation distr. function	p. 134
$f_c^{(N)}$	N -particle nonequil. canon. form	p. 41
$F_c^{(N)}$	Nonequilibrium canonical form of N particle ensemble	p. 144
$F_e^{(N)}$	Equil. grand partition function	p. 142
$g^{\mu\nu}$	Metric tensor	p. 3, 13
$g_a^{(q)}$	Eq. (1.314)	p. 61, 148, 157
g	Eq. (1.275)	p. 54, 147
$h_a^{(q)\mu\dots\nu}$	Nonconserved variable moment	p. 18, 19, 79
$h_r^{(q)\mu\dots\nu}$	Photon variable moment	p. 124
\hbar	Planck constant	p. 99
\mathcal{H}_a	Exponent of f_a^c	p. 133
$J_a^\mu, \widehat{J}_a^\mu$	Number diffusion flux	p. 9, 10, 12, 14, 115, 125
\mathbf{j}_a	Particle flux of a	p. 5
J_s^μ	Boltzmann entropy flux four-flow	p. 29, 30, 104, 166
J_c^μ	Caloertropy flux four-flow	p. 43, 44, 130
$\mathbf{J}_r [f f^c]$	Relative Boltzmann entropy flux	p. 45, 131
\mathbf{k}_r	Photon wave vector	p. 100
$M_a^{(q)\mu\dots\nu}$	Relativis. moment of a	p. 18
n_a	Number density	p. 5
N_a^μ	Particle four-flow of a	p. 5, 6, 8, 113, 122, 138
N^μ	Total number four-flow	p. 7, 8, 13
$p_a,$	Hydrostatic pressure	p. 11, 33
p	Pressure	p. 47, 52
p^e	Equil. pressure	p. 33, 36, 106
p_a^μ	Four-momentum	p. 2, 99
p_a^0	Time component of p_a^μ	p. 2
$\overline{\mathbf{p}}_b$	$:= \mathbf{p}_b / p_b^0$	p. 4
\mathbf{p}_r, p_r^μ	Photon momentum	p. 100, 101, 123, 125
$P_a^{\mu\nu}$	Pressure tensor	p. 11, 12, 78, 117
$\overline{P}^{\mu\nu}$	Decomposition of pressure tensor	p. 15
\mathbf{q}_r^μ	Dimensionless photon momentum	p. 123

Q_a^μ	Heat flux four-flow	p. 9, 10, 77
Q_e^μ	Projection of $T_e^{\mu\nu}$	p. 107
$Q_a^{\prime\mu}$	Modified heat flux 4-flow	p. 9, 10, 16, 65, 66
q_r, q_r^μ	Dimensionless photon momentum	p. 123
$q_L(\kappa)$	Nonlinear factor of thermdy. grad. Γ_κ	p. 72, 163
$q_n(\kappa)$	Nonlinear factor	p. 59
$\mathcal{R}^{(\pm)}$	Eqs. (1.281) and (1.282)	p. 55
$\mathbb{R}_{ab}^{(qs)\mu\dots\sigma\nu\dots\omega}$	Collision bracket integral	p. 56, 57
$\widehat{\mathbb{R}}_{ab}^{(qs)}$	Contracted coll. bracket integral	p. 57
$\mathbf{R}_{ab}^{(\alpha\gamma)\sigma\dots\mu\omega\dots\nu}$	Collision bracket integral tensor	p. 148
$\mathcal{R}_{ab}^{(\alpha\gamma)}$	Scalar collision bracket integral	p. 150, 151
S^μ	Boltzmann entropy 4-flow	p. 27, 103, 104, 162
$S^{e\mu}$	Equil. Boltzmann entropy 4-flow	p. 36
S	Scalar Boltzmann entropy	p. 27, 104, 166
S^e	Equil. Boltzmann entropy	p. 33, 34, 106, 107, 108
$S_r^\mu[f f^c], \widehat{S}_r[f f^c]$	Relative Boltzmann entropy, Rel. B. entropy density	p. 45, 82, 131
T^e	Equilibrium temperature	p. 34, 36, 37, 38, 108, 110
T	Temperature	p. 51, 135
$T_{ea}^{\mu\nu}$	Equil. energy-momentum tensor	p. 11, 36, 111
$T_a^{\mu\nu}$	Energy-momentum tensor	p. 5, 6, 11, 12, 112, 116, 163
U^μ	Hydrodynamic velocity	p. 3, 7, 13, 14, 67, 73, 114, 124, 159
U_{LR}^μ	Rest frame U^μ	p. 14
\mathbf{u}_a	Particle velocity of a	p. 5
\mathbf{u}	Total particle velocity	p. 5, 7
\mathbf{v}_a	Velocity of particle a	p. 5
v, v_a	Specific volume, of a	p. 9, 108, 116
$W_{ab}(p_a p_b p_a^* p_b^*)$	Transition rate	p. 4, 103
x^μ	Covariant four vector	p. 2
x_{ab}	$:= \omega_a + \omega_b$	p. 54
$X_a^{(q)\beta\gamma\dots\omega}$	General. potent. of a and order q	p. 61, 148, 151
$Z_a^{(q)\mu\dots\nu}$	Kinematic term	p. 21, 79, 121, 125, 168

German Symbols

\mathfrak{B}_{ab}	Eq. (1.310)	p. 60, 62, 70, 159
c_a	Mass fraction of a	p. 9, 12, 15, 52, 66, 106, 115, 116, 122, 145, 146
\mathfrak{C}_a^μ	Relativ. peculiar moment	p. 18, 19
\mathfrak{D}_{ab}	Eq. (1.309), diffusion coeff.	p. 60, 62, 70, 72, 162
\mathfrak{D}	Relativistic substantial time derivative	p. 20
\mathfrak{D}_{ab}	Diffusion coefficient	p. 60
\mathfrak{D}	Matrix of \mathfrak{D}_{ab}	p. 65, 160
\mathfrak{J}_a^μ	Mech. energy diffusion flow	p. 10, 115
h_a	Nonequil. enthalpy density	p. 9
\mathfrak{H}_{ab}	Eq. (1.300)	p. 60, 62, 63, 70, 72, 162
\mathfrak{H}	Matrix of \mathfrak{H}_{ab}	p. 65
\mathfrak{K}	Matrix of \mathfrak{K}_{ab}	p. 65
\mathfrak{K}_{ab}	Eq. (1.309)	p. 60, 62, 63, 70, 72, 162
p, p_a	Nonequil. pressure, (1.42)	p. 9, 11, 62, 63, 136, 138, 145, 146
p^e, p_i^e	Hydrostatic pressure	p. 111, 143
$\mathfrak{R}_{ab} [f_a f_b]$	Wang-Uhlenbeck coll. term	p. 101, 102, 111
$\mathfrak{R}_a [f_a]$	Collision term	p. 101
$\mathfrak{R}_{ab}^{(qs)}$	Eq. (1.300)	p. 58, 59, 60, 62, 63, 64, 69, 70
\mathfrak{T}_{ab}	Eq. (1.309)	p. 60, 62, 63, 70, 71, 72, 74
\mathfrak{T}	Matrix of \mathfrak{T}_{ab}	p. 65
\mathfrak{U}_{ab}	Eq. (1.310)	p. 60, 62, 63, 70, 71
$\mathfrak{Z}_a^{(q)\mu\dots\nu}$	Modified kinematic term	p. 21, 22, 80, 122, 126, 127, 128

Greek Symbols

β_e	Inverse temperature, $1/k_B T^e$	p. 35, 36, 37
β	Inverse temperature, $1/k_B T$	p. 133
γ	$:= 1/\sqrt{1 - (u/c)^2}$	p. 8
Γ_a^e	Normalization factor of $f_a^e(p_a)$	p. 33, 34, 35
Γ_r^e	Loc. equil. grand parti. f. of photon	p. 109
Γ_a	Normalization factor of $f_a^c(p_a)$	p. 40, 42
Γ	Normalization factor of $f_c^{(N)}$	p. 42, 46, 47, 49, 52
Γ^e	Normalization factor of $F_e^{(N)}$	p. 142, 143
$\Delta^{\mu\nu}$	Projector tensor	p. 3, 11, 13, 14, 17
$\tilde{\Delta}_a$	Excess normal stress	p. 11, 12, 16, 64, 68
$\hat{\Delta}_a$	Excess normal stress	p. 68
$\Theta_a^{(q)\sigma\mu\dots\nu}$	Divergence term	p. 22, 24, 25, 122, 127, 154
$\kappa, \kappa_2, \kappa_3$	First, second, third cumulant, Rayleigh dissipation function	p. 56, 59, 60, 61, 68, 69, 70
$\bar{\kappa}_R$	Rossland coefficient	p. 179
$\lambda_{ab}^0, \lambda_a^0$	Thermal conductivity	p. 66, 161, 175, 177, 187
λ_{ab}, λ_a	Nonlinear thermal conductivity	p. 73, 163
$\Lambda_a^{(q)\sigma\mu\dots\nu}$	Dissipation term of a and order q	p. 20, 21, 22, 49, 59, 121, 122, 125, 126, 127, 128, 157, 167, 168
μ_a^e	Equil. chemical potential of a	p. 32, 34, 35, 36
μ_r^e	Photon chemical potential	p. 108
η_a^0, η^0	Viscosity	p. 64, 66, 161, 175, 177, 179, 187
η_a	Non-Newtonian viscosity	p. 162, 163
η_{Ba}^0, η_B^0	Bulk viscosity	p. 64, 66, 175, 177
η_B	Nonlinear bulk viscosity	p. 73, 163
Ξ_e	Equil. grand canon. partition func.	p. 107, 143
Ξ	Nonequil. grand partition func.	p. 42, 47, 145
$\Pi^{\mu\nu}$	Shear stress tensor	p. 12, 16, 64, 68, 70, 117, 122
ρ	Hydrodynamic density	p. 7, 8, 9, 12, 14, 15, 16, 20, 21
ρ_r	Photon number density	p. 109, 110
σ_{ent}	Boltzmann entropy production	p. 28, 29, 30, 104, 105

σ_c	Calortropy production	p. 43, 44, 55, 56, 59, 130, 131
$\bar{\sigma}_c$	Reduced calortropy production	p. 55
$\sigma_r[f f^c]$	Relative Boltzmann entropy prod.	p. 45
Σ_c	Kinematic term of calortropy bal. eq.	p. 130, 131
Υ_a	Normalization factor of f_a	p. 81, 82
$\psi_a^{(q)\mu\dots\nu}$	Supermoment of moment $h_a^{(q)\mu\dots\nu}$	p. 16, 20, 22, 80, 120, 121
$\Psi, \widehat{\Psi}$	Scalar calortropy, density of Ψ	p. 43, 44, 45, 46, 47, 48, 49, 50, 129, 136
$\widehat{\Psi}_m, \widehat{\Psi}_r$	Calortropy density	p. 136
$\Phi_a^{(q)\mu\dots\nu}$	Flux tensor, projection of supermoment onto U_σ	p. 16, 20, 21, 22, 25, 41, 49, 61, 71, 120, 121, 122, 124, 125, 127, 128
χ_a	Thermodynamic gradient	p. 158, 159, 162
$\Omega_a^{(q)\sigma\mu\dots\nu}$	Projection of supermoment	p. 20, 21
ω	Photon frequency	p. 100

Mathematical Operations

$\langle\langle A \rangle\rangle$	Collision average	p. 55
d_t	$:= \partial_t + \mathbf{u} \cdot \nabla$	p. 75
D	$:= U^\mu \partial_\mu$	p. 13, 75, 165
D_{LR}	Local rest frame $\partial/\partial t$	p. 14
\mathfrak{D}	Relativ. subst. time derivat.	p. 20, 115
$\partial^\mu, \partial_\mu$	Covariant, contravariant gradient operator	p. 3, 13, 75
∇^μ, ∇_μ	Covariant, contravariant spatial gradient operator	p. 13
∇_{LR}^k	Local rest frame $-\partial/\partial x^k$	p. 14
M_a	Mean value of observable M_a	p. 6
$[\mathbf{P}]^{(2)}$	Traceless symmetric part of \mathbf{P}	p. 22
$[\nabla U]^{(2)\mu\nu}$	Eq. (2.275)	p. 158
$[A^{\mu\dots\sigma} B^{\nu\dots\omega}]_{ab}$	Collision bracket integral	p. 57, 148
$\langle A_a(x, p_a) \rangle$	Mean value, relativistic	p. 103
$[p_a p_a]^{(2)\omega\varepsilon}$	$:= p_a^\omega p_a^\varepsilon - \frac{1}{3} \Delta^{\omega\varepsilon} (p_a^\sigma p_{a\sigma})$	p. 155

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