VISCOSITY OF A PARTIALLY IONIZED TWO-TEMPERATURE PLASMA

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In [2] a system of equations for the distribution functions of the first approximation in a partially ionized two-temperature plasma in the presence of a magnetic field was derived using the Chapman-Enskog method [1]. In this article, the part of the distribution function of the first approximation associated with viscosity is found. An expression is obtained for the viscosity tensor for an arbitrarily directed magnetic field.

1. We shall denote the equations of [2] by an asterisk (*). Factoring out the term with the independent parameter from Eq. (3.3)*, whose solution was sought in the form (3.6)*, we obtain

$$f_\alpha^\circ \frac{m_\alpha}{kT_\alpha}\left(v_{\alpha i}v_{\alpha k} - \frac{1}{3}v_\alpha^2\delta_{ik}\right)\frac{\partial c_{0i}}{\partial x_k} = = f_\alpha^\circ \frac{e_\alpha}{m_\alpha c}\varepsilon_{lpq}v_{\alpha p}B_q\frac{\partial}{\partial v_{\alpha l}}\left(G_{\alpha ik}\frac{\partial c_{0i}}{\partial x_k}\right) + I_\alpha\left(G_{\alpha ik}\frac{\partial c_{0i}}{\partial x_k}\right). \qquad (1.1)$$

Here f_α° is the Maxwell distribution function for particles of type α, e_α, m_α, T_α are the charge, mass, and temperature of particles of type α. The subscript $\alpha = 1, 2, 3$, respectively, for singly-charged ions, electrons, and neutral particles; B_i is the magnetic induction, ε_{ikl} a permutation tensor, c the speed of light, $v_{\alpha i}$ the velocity of a particle of type α, c_{0i} the mean mass velocity, and $G_{\alpha ik}$ is the part of the distribution function associated with viscosity. It is assumed that $T_1 = T_3 = T \neq T_2$.

The integrals I_α are given by (3.4)*. It is shown in [1] that owing to the structure of Eq. (1.1) the tensor $G_{\alpha ik}$ must be symmetric and without divergence, i. e.,

$$G_{\alpha ik} = G_{\alpha ki}, \qquad G_{\alpha ii} = 0\,. \qquad (1.2)$$

From the polar vector v_i and the axial vector B_i we can construct five true tensors whose symmetric divergenceless parts will be linearly independent [3, 4].

We shall choose

$$\begin{gathered} T_{\alpha 1ik} = v_{\alpha i}v_{\alpha k} - {}^1/_3 v_\alpha^2\delta_{ik}, \qquad T_{\alpha 2ik} = B_iB_kB_sB_t\,(v_{\alpha s}v_{\alpha t} - {}^1/_3 v_\alpha^2\delta_{st}), \\ T_{\alpha 3ik} = B_iB_s\,(v_{\alpha k}v_{\alpha s} - {}^1/_3 v_\alpha^2\delta_{ks}), \qquad T_{\alpha 4ik} = B_t\varepsilon_{ist}\,(v_{\alpha k}v_{\alpha s} - {}^1/_3 v_\alpha^2\delta_{ks}), \\ T_{\alpha 5ik} = \varepsilon_{ksl}B_iB_lB_n\,(v_{\alpha s}v_{\alpha n} - {}^1/_3 v_\alpha^2\delta_{sn}), \end{gathered} \qquad (1.3)$$

as the independent tensors and introduce the notation

$$\{T_{ik}\} = {}^1/_2\,(T_{ik} + T_{ki} - {}^2/_3\,T_{jj}\delta_{ik})\,. \qquad (1.4)$$

We shall seek a solution of system (1.1) in the form

$$G_{\alpha ik} = \sum_{\gamma=1}^{5} G_{\alpha\gamma}\{T_{\alpha\gamma ik}\}\,. \qquad (1.5)$$

It is assumed that $G_{\alpha\gamma}$ are functions of the scalars v_α^2 and B^2. Substituting (1.5) into (1.1) and carrying out transformations using the rules of tensor algebra [5], we obtain

$$f_\alpha^\circ \frac{m_\alpha}{kT_\alpha}T_{\alpha 1ik}\left\{\frac{\partial c_{0i}}{\partial x_k}\right\} = f_\alpha^\circ \frac{e_\alpha}{m_\alpha c}\left\{\frac{\partial c_{0i}}{\partial x_k}\right\}[2G_{\alpha 1}T_{\alpha 4ik} + G_{\alpha 3}T_{\alpha 5ik} + + 3G_{\alpha 4}T_{\alpha 3ik} - 2B^2G_{\alpha 4}T_{\alpha 1ik} + G_{\alpha 5}(T_{\alpha 2ik} - B^2T_{\alpha 3ik})] + I_\alpha\left(\sum_{\gamma=1}^{5} G_{\alpha\gamma}T_{\alpha\gamma ik}\left\{\frac{\partial c_{0i}}{\partial x_k}\right\}\right), \qquad (1.6)$$

We factor out from (1. 6) the coefficients of the following independent parameters:

$$\left\{\frac{\partial c_{0i}}{\partial x_k}\right\}, \quad B_iB_kB_sB_t\left\{\frac{\partial c_{0s}}{\partial x_t}\right\}, \quad B_iB_s\left\{\frac{\partial c_{0s}}{\partial x_k}\right\}, \quad \varepsilon_{sil}B_t\left\{\frac{\partial c_{0s}}{\partial x_k}\right\}, \quad \varepsilon_{skl}B_nB_lB_i\left\{\frac{\partial c_{0n}}{\partial x_s}\right\}, \tag{1. 7}$$

and introduce the variables .

$$\eta_\alpha = G_{\alpha 1} + iBG_{\alpha 4}, \qquad \lambda_\alpha = G_{\alpha 3} + iBG_{\alpha 5}. \tag{1. 8}$$

Then, going over to the dimensionless velocity $u_{\alpha i} = (m_\alpha / 2kT_\alpha)^{1/2} v_{\alpha i}$, we obtain the systems of equations:

$$f_\alpha{}^\circ\{u_{\alpha i}u_{\alpha k}\} = if_\alpha{}^\circ \frac{2e_\alpha B}{m_\alpha c}\frac{kT_\alpha}{m_\alpha}\eta_\alpha\{u_{\alpha i}u_{\alpha k}\} + \frac{kT_\alpha}{m_\alpha}I_\alpha(\eta_\alpha\{u_{\alpha i}u_{\alpha k}\}), \tag{1. 9}$$

$$-f_\alpha{}^\circ\frac{e_\alpha}{m_\alpha c}3G_{\alpha 4}\{u_{\alpha i}u_{\alpha k}\} = if_\alpha{}^\circ\frac{e_\alpha B}{m_\alpha c}\lambda_\alpha\{u_{\alpha i}u_{\alpha k}\} + I_\alpha(\lambda_\alpha\{u_{\alpha i}u_{\alpha k}\}), \tag{1. 10}$$

$$-f_\alpha{}^\circ\frac{e_\alpha}{m_\alpha c}G_{\alpha 5}\{u_{\alpha i}u_{\alpha k}\} = I_\alpha(G_{\alpha 2}\{u_{\alpha i}u_{\alpha k}\}). \tag{1. 11}$$

Systems (1. 9)-(1. 11) must be solved successively. However, from (1. 6) it is easy to obtain the equation

$$f_\alpha{}^\circ\frac{m_\alpha}{kT_\alpha}\{v_{\alpha i}v_{\alpha k}\} = I_\alpha\left[\left(G_{\alpha 1} + \frac{2}{3}B^2G_{\alpha 3} + \frac{2}{3}B^4G_{\alpha 2}\right)\{v_{\alpha i}v_{\alpha k}\}\right].$$

The quantity $G_{\alpha 1} + {}^2/_3B^2G_{\alpha 3} + {}^2/_3B^4G_{\alpha 2}$ satisfies the same equation obtained for $G_{\alpha 1}$ when $B = 0$. Consequently,

$$(G_{\alpha 1})_{B=0} = G_{\alpha 1} + {}^2/_3B^2G_{\alpha 3} + {}^2/_3B^4G_{\alpha 2}. \tag{1. 12}$$

Thus, we may use (1. 12) to find $G_{\alpha 2}$ instead of the solution to (1. 11). Following [1], we will seek $G_{\alpha\gamma}$ in the form of a series expansion in Sonine polynomials $S_{5/2}^{(p)}(x)$, defined as [1]:

$$(1-s)^{-7/2}\exp\frac{-xs}{1-s} = \sum_{p=0}^{\infty} S_{5/2}^{(p)}(x)\, s^p, \tag{1. 13}$$

$$\int_0^\infty S_{5/2}^{(p)}(x)\, S_{5/2}^{(q)}(x)\, e^{-x}x^{5/2}dx = \frac{\Gamma(7/2+p)}{p!}\delta_{pq}. \tag{1. 14}$$

We have

$$G_{\alpha\gamma} = \sum_{p=0}^{\infty} g_{\alpha\gamma p}S_{5/2}^{(p)}(u_\alpha{}^2). \tag{1. 15}$$

For $\nu_{\alpha p} = g_{\alpha 1p} + iBg_{\alpha 4p}$, we obtain the infinite system of linear algebraic equations

$$\begin{aligned}\frac{5}{2}n_\alpha\delta_{0p} = i\omega_\alpha\frac{kT_\alpha}{m_\alpha}n_\alpha\frac{8}{3\sqrt{\pi}}\frac{\Gamma(p+7/2)}{p!}\nu_{\alpha p} + \frac{kT}{m_1}\sum_{r=0}^{\infty}b_{pr}^{\alpha 1}\nu_{1r} + \\ + \frac{kT_2}{m_2}\sum_{r=0}^{\infty}b_{pr}^{\alpha 2}\nu_{2r} + \frac{kT}{m_3}\sum_{r=0}^{\infty}b_{pr}^{\alpha 3}\nu_{3r} \qquad \left(\alpha = 1, 2, 3;\ p \geqslant 0;\ \omega_\alpha = \frac{e_\alpha B}{m_\alpha c}\right)\end{aligned} \tag{1. 16}$$

by substituting the expansion (1. 15) into (1. 9), multiplying the obtained expression by $S_{5/2}^{(p)}(u_\alpha{}^2)\{u_{\alpha i}u_{\alpha k}\}$, integrating with respect to $dc_{\alpha i}$, and using the fact that the Sonine polynomials (1. 14) are orthogonal.

The values of $b_{pq}^{\alpha\beta}$ are determined in the following manner:

$$\begin{aligned}b_{pq}^{\alpha\alpha} = \int f_\alpha{}^\circ f^\circ S_{5/2}^{(p)}(u_\alpha{}^2)\{u_{\alpha i}u_{\alpha k}\}\,[S_{5/2}^{(q)}(u_\alpha{}^2)\{u_{\alpha i}u_{\alpha k}\} + S_{5/2}^{(q)}(u^2)\{u_iu_k\} - \\ - S_{5/2}^{(q)}(u_\alpha{}'^2)\{u_{\alpha i}'u_{\alpha k}'\} - S_{5/2}^{(q)}(u'^2)\{u_i'u_k'\}]\, g_{\alpha\alpha}b\,db\,d\varepsilon\,dc_idc_{\alpha i} + \\ + \sum_{\beta\neq\alpha}\int S_{5/2}^{(p)}(u_\alpha{}^2)\{u_{\alpha i}u_{\alpha k}\}\,[f_\alpha{}^\circ f_\beta{}^\circ S_{5/2}^{(q)}(u_\alpha{}^2)\{u_{\alpha i}u_{\alpha k}\} - \\ - f_\alpha{}^{\circ\prime}f_\beta{}^{\prime\circ}S_{5/2}^{(q)}(u_\alpha{}'^2)\{u_{\alpha i}'u_{\alpha k}'\}]\, g_{\alpha\beta}b\,db\,d\varepsilon\,dc_{\beta i}dc_{\alpha i},\end{aligned} \tag{1. 17}$$

$$b_{pq}^{\alpha\beta}=\int S_{3/2}^{(p)}(u_\alpha^2)\{u_{\alpha i}u_{\alpha k}\}\,[f_\alpha{}^\circ f_\beta{}^\circ S_{3/2}^{(q)}(u_\beta^2)\{u_{\beta i}u_{\beta k}\}- \tag{1. 17 (cont'd)}$$

$$-f_\alpha{}^{\circ\prime} f_\beta{}^{\circ\prime} S_{3/2}^{(q)}(u_\beta'^2)\{u_{\beta i}'u_{\beta k}'\}]\,g_{\alpha\beta}b\,db\,d\varepsilon\,dc_{\beta i}dc_{\alpha i}\quad (\alpha,\beta=1,2,3;\ \alpha\neq\beta).$$

Similarly, for the coefficients $\mu_{\alpha p}=g_{\alpha 3p}+iBg_{\alpha 5p}$, we obtain from (1. 10) and (1. 15)

$$-\frac{4}{\sqrt{\pi}}\frac{\Gamma(p+7/2)}{p!}n_\alpha\frac{e_\alpha}{m_\alpha c}g_{\alpha 4p}=i\frac{4}{3\sqrt{\pi}}\frac{\Gamma(p+7/2)}{p!}\omega_\alpha n_\alpha \mu_{\alpha p}+$$

$$+\frac{m_\alpha T}{m_1 T_\alpha}\sum_{r=0}^{\infty}b_{pr}^{\alpha 1}\mu_{1r}+\frac{m_\alpha T_2}{m_2 T}\sum_{r=0}^{\infty}b_{pr}^{\alpha 2}\mu_{2r}+\frac{m_\alpha T}{m_3 T_\alpha}\sum_{r=0}^{\infty}b_{pr}^{\alpha 3}\mu_{3r}\quad (\alpha=1,2,3;\ p\geqslant 0). \tag{1. 18}$$

For the coefficients $g_{\alpha 2p}$, we obtain from (1. 12)

$$^{2}/_{3}B^4 g_{\alpha 2r}=(g_{\alpha 1r})_{B=0}-{}^{2}/_{3}B^2 g_{\alpha 3r}-g_{\alpha 1r}. \tag{1. 19}$$

Systems (1. 16) and (1. 18) are solved successively using the Cramer rule.

2. By definition [1], the viscous stress tensor is

$$\pi_{\alpha ik}=\Pi_{\alpha ik}-p_\alpha\delta_{ik}. \tag{2. 1}$$

Making use of the definition of $\Pi_{\alpha ik}$ and P_α in (1. 9)* and (3. 1)*, we obtain

$$\pi_{\alpha ik}=n_\alpha m_\alpha\langle v_{\alpha i}v_{\alpha k}-{}^{1}/_{3}v_\alpha{}^2\delta_{ik}\rangle. \tag{2. 2}$$

Only the term with $G_{\alpha ik}$ makes a contribution to the viscous stress tensor $\pi_{\alpha ik}$ [1]. Using the definitions (2. 2) and (1. 9)*, the expansions (3. 6)* and (1. 15), the fact that the Sonine polynomials in (1. 14) are orthogonal, and the relationship

$$\int\varphi(v)\{v_iv_k\}\{v_pv_q\}\,dc_i=\frac{1}{15}\left(\delta_{ip}\delta_{kq}+\delta_{iq}\delta_{kp}-\frac{2}{3}\delta_{ik}\delta_{pq}\right)\int\varphi(v)\,v^4dc_i, \tag{2. 3}$$

which is easily verifiable for the isotropic function $\varphi(v)$, we obtain

$$\pi_{\alpha ik}=-2\mu_{\alpha ikpq}\left\{\frac{\partial c_{0\pi}}{\partial x_q}\right\}\qquad \mu_{\alpha ikpq}=\frac{(kT_\alpha)^2}{m_\alpha}n_\alpha\Big[g_{\alpha 10}\delta_{ip}\delta_{kq}+$$

$$+g_{\alpha 20}\left(B_iB_k-\frac{1}{3}\delta_{ik}B^2\right)B_pB_q+\frac{1}{2}g_{\alpha 30}\Big(B_iB_p\delta_{kq}+B_kB_p\delta_{iq}- \tag{2. 4}$$

$$-\frac{2}{3}\delta_{ik}B_pB_q\Big)+\frac{1}{2}g_{\alpha 40}(\varepsilon_{pil}B_l\delta_{qk}+\varepsilon_{pkl}B_l\delta_{qi})+\frac{1}{2}g_{\alpha 50}(\varepsilon_{qil}B_pB_lB_k+\varepsilon_{qkl}B_pB_lB_i)\Big].$$

The quantity $\mu_{\alpha ikpq}$ is the viscosity tensor for α-type particles in a magnetic field. A general expression for the viscosity tensor for an arbitrarily directed magnetic field was obtained by taking the system of independent tensors in the form (1. 3). In [6] a general expression was not obtained for the viscosity tensor, another system of independent tensors being chosen. To find the viscosity tensor, it is necessary to know only the first coefficient in (1. 15).

3. We leave a single Sonine polynomial in expansions (1. 15). The quantities $b_{00}^{\alpha\beta}$, given by (1. 17), have the form

$$b_{00}^{11}=\frac{3n\alpha}{\tau_1}+\frac{y_1}{\tau_{13}}n\alpha(1-\alpha),\qquad b_{00}^{13}=b_{00}^{31}=-\frac{y_2}{\tau_{13}}n\alpha(1-\alpha)$$

$$b_{00}^{22}=\left(\frac{3}{\sqrt{2}}+3\right)\frac{n\alpha}{\tau_2}+\frac{y_3}{\tau_{23}}n\alpha(1-\alpha) \tag{3. 1}$$

$$b_{00}^{33}=\frac{n(1-\alpha)}{\tau_3}+\frac{y_1}{\tau_{13}}n\alpha(1-\alpha),\qquad b_{00}^{12},\ b_{00}^{21}\sim\frac{m_2}{m}\frac{n\alpha}{\tau_2}\qquad b_{00}^{32},\ b_{00}^{23}\sim\frac{m_2}{m}\frac{n\alpha(1-\alpha)}{\tau_{23}}$$

if we ignore quantities $\sim(m_2/m)^{1/2}$ in comparison with unity.

To compute (3. 1) conditions (5. 7)* were used. The quantities τ_α and $\tau_{\alpha\beta}$ are given by (5. 2)*. The structure of systems (1. 16) and (1. 18) is such that, if we neglect quantities $\sim(m_2/m)^{1/2}$ in comparison with unity, we do not need to know the elements b_{00}^{32} and b_{00}^{23} exactly, since due to their smallness they do not appear in the final results. For Maxwellian interaction between neutral and charged particles, we have

$$y_1 = 8.32, \qquad y_2 = 1.06, \qquad y_3 = 10.3\,. \tag{3.2}$$

For any interaction, we have the relations [1]:

$$\frac{y_1}{n\tau_{13}} = \frac{4}{3}\left[5\Omega_{13}^{(1)}(1) + \frac{3}{2}\Omega_{13}^{(2)}(2)\right] \qquad \frac{y_3}{n\tau_{23}} = 8\Omega_{23}^{(2)}(2)$$
$$\frac{y_2}{n\tau_{13}} = \frac{4}{3}\left[5\Omega_{13}^{(1)} - \frac{3}{2}\Omega_{13}^{(2)}(2)\right]. \tag{3.3}$$

Here $\Omega_{\beta 3}^{(l)}(p)$ are given by (5.9)*. The temperature ratio for electrons and heavy particles is always linearly dependent on the mass ratio and, being much smaller than the ratio of the masses of the heavy particles and electrons, does not affect the order of the elements $b_{00}^{\alpha 2}$ and $b_{00}^{2\alpha}$ ($\alpha = 1, 3$). The limitation on the temperature ratio follows from the conditions of applicability of the Boltzmann equations [7]. The solution of system (1.16), taking into account (3.1), has the form

$$\begin{aligned}
g_{110} &= \frac{5}{6}\frac{m}{kT}\tau_1\Gamma_1\frac{1 + y_2(1-\alpha)(\tau_3/\tau_{13} + y_1\alpha\tau_3)}{\Gamma_1^2 + {}^{25}/_9\,\omega_1^2\tau_1^2},\\
g_{140} &= -\frac{25}{18}\frac{m}{kT}\tau_1\frac{\omega_1\tau_1}{B}\frac{1 + y_2(1-\alpha)(\tau_3/\tau_{13} + y_1\alpha\tau_3)}{\Gamma_1^2 + {}^{25}/_9\,\omega_1^2\tau_1^2},\\
g_{310} &= \frac{5}{2}\frac{m}{kT}\tau_3\frac{\Gamma_1\Gamma_2 + ({}^{25}/_9)\,\omega_1^2\tau_1^2}{[\Gamma_1^2 + {}^{25}/_9\,\omega_1^2\tau_1^2]\,[1 + y_1\alpha(\tau_3/\tau_{13})]},\\
g_{340} &= \frac{25}{6}\frac{m}{kT}\tau_3\frac{\Gamma_1 - \Gamma_2}{[\Gamma_1^2 + {}^{25}/_9\,\omega_1^2\tau_1^2]\,[1 + y_1\alpha(\tau_3/\tau_{13})]}\\
g_{210} &= \frac{5}{3(2+\sqrt{2})}\frac{m_2\tau_2}{kT_2}\frac{1 + [2y_3(1-\alpha)\tau_2/3(2+\sqrt{2})\tau_{23}]}{\{1+[2y_3\tau_2(1-\alpha)/3(2+\sqrt{2})\tau_{23}]\}^2 + [{}^3/_{10}(2+\sqrt{2})]^{-2}\omega_2^2\tau_2^2},\\
g_{240} &= \frac{50}{9(2+\sqrt{2})^2}\frac{m_2}{kT_2}\frac{\omega_2\tau_2}{B}\left\{\left[1 + \frac{2y_3(1-\alpha)\tau_2}{3(2+\sqrt{2})\tau_{23}}\right]^2 + \frac{100}{9(2+\sqrt{2})^2}\omega_2^2\tau_2^2\right\}^{-1},
\end{aligned} \tag{3.4}$$

where

$$\Gamma_1 = 1 + \frac{y_3\tau_1(1-\alpha)}{3\tau_{13}} - \frac{y_2^2\tau_1\tau_3\alpha(1-\alpha)}{\tau_{13}^2[1 + y_1\alpha(\tau_3/\tau_{13})]}, \quad \Gamma_2 = 1 + \frac{y_1\tau_1(1-\alpha)}{3\tau_{13}} + \frac{y_2\tau_1\alpha}{3\tau_3}\,. \tag{3.5}$$

Using (3.1) and (3.4), we obtain the solution of system (1.18) in the form

$$\begin{aligned}
g_{130} &= \frac{25}{6}\frac{\omega_1^2\tau_1^2}{B^2}\frac{g_{110}}{\Gamma_1^2 + {}^{25}/_{36}\,\omega_1^2\tau_1^2}, \qquad g_{150} = \frac{25}{12}\frac{\omega_1^2\tau_1^2}{B^2}\frac{g_{140}}{\Gamma_1^2 + {}^{25}/_{36}\,\omega_1^2\tau_1^2},\\
g_{330} &= \frac{25}{6}\frac{\omega_1^2\tau_1^2}{B^2}\frac{y_2(1-\alpha)(\tau_3/\tau_{13} + y_1\alpha\tau_3)\,g_{110}}{\Gamma_1^2 + {}^{25}/_{36}\,\omega_1^2\tau_1^2},\\
g_{350} &= \frac{25}{12}\frac{\omega_1^2\tau_1^2}{B^2}\frac{y_2(1-\alpha)(\tau_3/\tau_{13} + y_1\alpha\tau_3)\,g_{140}}{\Gamma_1^2 + {}^{25}/_{36}\,\omega_1^2\tau_1^2},\\
g_{230} &= \frac{25}{3(1+\sqrt{2})^2}\frac{\omega_2^2\tau_2^2}{B^2}g_{210}\left\{\left[1 + \frac{2y_3(1-\alpha)\tau_2}{3(2+\sqrt{2})\tau_{23}}\right]^2 + \frac{25}{9(2+\sqrt{2})^2}\omega_2^2\tau_2^2\right\}^{-1},\\
g_{250} &= \frac{25}{6(1+\sqrt{2})^2}\frac{\omega_2^2\tau_2^2}{B^2}g_{240}\left\{\left[1 + \frac{2y_3(1-\alpha)\tau_2}{3(2+\sqrt{2})\tau_{23}}\right]^2 + \frac{25}{9(2+\sqrt{2})^2}\omega_2^2\tau_2^2\right\}^{-1}.
\end{aligned} \tag{3.6}$$

The coefficients $g_{\alpha 20}$ are found from (1.19):

$$g_{\alpha 20} = \frac{3}{2B^4}(g_{\alpha 10})_{B=0} - \frac{1}{B^2}g_{\alpha 30} - \frac{3}{2B^4}g_{\alpha 10}\,. \tag{3.7}$$

From (3.4)-(3.7) with $\alpha = 1$ and a magnetic field directed along the x-axis, for the ion stress tensor π_{1ik}, we obtain the relations of [1] with the corrections made in [6]. For $\alpha = 0$, we obtain the first-approximation formula for the viscosity coefficient of a simple gas [1]

$$\mu_3 = \frac{5}{16}\frac{\sqrt{kmT}}{\sqrt{\pi}\,\sigma^2}\frac{1}{\Omega^{(2,2)*}} \tag{3.8}$$

from the expression for g_{310} taking into account (5. 2)* and (2. 5).

For an elastic ball model $\Omega^{(2,2)*} = 1$.

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