Abstract

The new generalized kinetic equation is offered. This equation represents a hybrid of Shakhov’s equation and ellipsoidal statistical equation of Holway. Equation constants are expressed through such physically significant quantities, as viscosity of gas, its heat conductivity and self-diffusion coefficient. Then these quantities are expressed through integral brackets.

**Key words:** Shakhov’s equation, ellipsoidal statistical Holway’s equation, rarefied gas, constans of equation, Ferziger’s number, Prandtl number, gas macroparameters.

PACS numbers: 05.20. Dd Kinetic theory, 51.10.+y Kinetic and transport theory of gases, 47.45.Ab Kinetic theory of gases

Introduction

In the present work the new generalized kinetic equation is entered. This equation represents a hybrid of Shakhov’s equation [1] and ellipsoidal statistical Holway’s equation [2], [3].

Such equation was entered already in works [4] – [7]. However, in these works constants of equations have not been expressed through physically significant macroparameters, and were considered as numerical parameters of Shakhov—Holway equations, connected only with Prandtl number.

In work [4] for Holway—Shakhov equation the classical problem of the kinetic theory (a Kramers’ problem about isothermal sliding) has been solved. Its decision was presented in quadratures.

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In work \[5\] solution of boundary value Riemann–Hilbert problem from theory of functions of complex variable was presented. To this problem the solution of known Smoluchovsksky problem about temperature jump is reduced.

In work \[6\] specification of the solution of Kramers’ problem from \[4\] is given and the solution of thermal sliding problem also is presented.

In work \[7\] the solution of Smoluchovsky’ problem has been given for ellipsoidal statistical equation. In this work the numerical parameter mattered, leading to correct Prandtl number for model of the rarefied gas consisting from molecules—solid spheres.

Equation constants are expressed through such physically significant quantities, as viscosity of gas, its heat conductivity and self-diffusion coefficient.

### 1. Kinetic Holway—Shakhov equation

Let’s consider the hybrid of linear Shakhov equation (see, for example, \[1\]) and ellipsoidal statistical Holway equation (see \[3\])

$$
\frac{\mathbf{v}}{\partial \mathbf{r}} \partial h = -\nu h(\mathbf{r}, \mathbf{v}) + \nu \frac{\delta n(\mathbf{r})}{n_0} + 2\nu \left( \frac{m}{2kT_0} \right) \mathbf{v} \mathbf{u}(\mathbf{r}) + 
+ \nu \left( \frac{mv^2}{2kT_0} - \frac{3}{2} \right) \frac{\delta T(\mathbf{r})}{T_0} + \nu \gamma \sqrt{\frac{m}{2kT_0}} \mathbf{v} \left( \frac{mv^2}{2kT_0} - \frac{5}{2} \right) Q(\mathbf{r}) + 
+ \nu \omega \left( \frac{m}{2kT_0} \right) \sum_{i,j=1}^{3} \left( v_i v_j - \frac{\delta_{ij}}{3} v^2 \right) P_{ij}(\mathbf{r}). \quad (1.1)
$$

Parameters $\nu, \gamma, \omega$ are number parameters of equation, thus the parameter $\nu$ makes sense as effective collision frequency of gas molecules.

At $\omega = 0$ the equation (1.1) transforms to Shakhov’s equation, and at $\gamma = 0$ transforms to ellipsoidal statistical Holway’s equation.
Function $h(r, v)$, named more low the distribution function, is relative perturbation to absolute Maxwellian $f_0(v)$,

$$f_0(v) = n_0 \left( \frac{m}{2kT_0} \right)^{3/2} \exp \left( - \frac{mv^2}{2kT_0} \right),$$

and quantities $n_0, T_0$ are concentration (number density) and gas temperature in some point $r_0$ of gas volume.

At the solution of concrete half-space problems this point gets out in some point of a surface, for example, in the origin of coordinates.

Besides, in (1.1) following designations are accepted, $\delta n(r) = n(r) - n_0$ is the deviation local concentration of gas from values $n_0$,

$$\frac{\delta n(r)}{n_0} = \frac{\beta^{3/2}}{\pi^{3/2}} \int \exp(-\beta v'^2) h(r, v') d^3v',$$  \hspace{1cm} (1.2)

where $\beta = m/(2kT_0)$, further $u(r)$ is the mass gas velocity, $U(r)$ is the dimensionless mass gas velocity, $U(r) = \sqrt{\beta} u(r)$,

$$u(r) = \frac{\beta^{3/2}}{\pi^{3/2}} \int \exp(-\beta v'^2) v' h(r, v') d^3v',$$ \hspace{1cm} (1.3)

$\delta T(r) = T(r) - T_0$ is the local deviation of gas temperature from some value $T_0$,

$$\frac{\delta T(r)}{T_0} = \frac{2\beta^{3/2}}{3\pi^{3/2}} \int \exp(-\beta v'^2) \left( \beta v'^2 - \frac{3}{2} \right) h(r, v') d^3v',$$ \hspace{1cm} (1.4)

$Q(r)$ is the dimensionless vector of heat stream,

$$Q(r) = \frac{\beta^2}{\pi^{3/2}} \int \exp(-\beta v'^2) v' \left( \frac{mv^2}{2} - \frac{5kT_0}{2} \right) h(r, v') d^3v',$$ \hspace{1cm} (1.5)

$P_{ij}(r)$ are these dimensionless components of viscous stress tensor,
\[ P_{ij}(\mathbf{r}) = \frac{\beta^{5/2}}{\pi^{3/2}} \int \exp(-\beta v'^2) \left( v'_i v'_j - \frac{\delta_{ij}}{3} v'^2 \right) h(\mathbf{r}, \mathbf{v}') d^3v'. \quad (1.6) \]

Let’s transform the equation (1.1), having entered dimensionless velocity of gas molecules \( C = \sqrt{\beta} \mathbf{v} \). We have

\[
C \frac{\partial h}{\partial \mathbf{r}} = \nu \sqrt{\beta} \left[ -h(\mathbf{r}, C) + \frac{\delta n(\mathbf{r})}{n_0} + 2CU(\mathbf{r}) + \left( C^2 - \frac{3}{2} \right) \frac{\delta T(\mathbf{r})}{T_0} + \gamma C \left( C^2 - \frac{5}{2} \right) Q(\mathbf{r}) + \omega \sum_{i,j=1}^{3} \left( C_i C_j - \frac{\delta_{ij}}{3} C^2 \right) P_{ij}(\mathbf{r}) \right]. \quad (1.7)
\]

Here \( \mathbf{r} \) is the dimension coordinate.

The right part of the equation (1.7) is the linear integral of collisions. In the equation (1.7)

\[
\frac{\delta n(\mathbf{r})}{n_0} = \frac{1}{\pi^{3/2}} \int \exp(-C'^2) h(\mathbf{r}, C') d^3C', \quad (1.2')
\]

\[
U(\mathbf{r}) = \sqrt{\beta} u(\mathbf{r}) = \frac{1}{\pi^{3/2}} \int \exp(-C'^2) C' h(\mathbf{r}, C') d^3C', \quad (1.3')
\]

\[
\frac{\delta T(\mathbf{r})}{T_0} = \frac{2}{3\pi^{3/2}} \int \exp(-C'^2) \left( C'^2 - \frac{3}{2} \right) h(\mathbf{r}, C') d^3C', \quad (1.4')
\]

\[
Q(\mathbf{r}) = \frac{1}{\pi^{3/2}} \int \exp(-C'^2) C' \left( C^2 - \frac{5}{2} \right) h(\mathbf{r}, C') d^3C', \quad (1.5')
\]

\[
P_{ij}(\mathbf{r}) = \frac{1}{\pi^{3/2}} \int \exp(-C'^2) \left( C'_i C'_j - \frac{\delta_{ij}}{3} C'^2 \right) h(\mathbf{r}, C') d^3C', \quad (1.6')
\]
Let’s notice, that a dimensionless heat stream is connected with a dimensional heat stream

\[
q(r) = n_0 \frac{\beta^{3/2}}{\pi^{3/2}} \int \exp(-\beta v^2) v \left( \frac{mv^2}{2} - \frac{5kT}{2} \right) h(r, v) d^3v
\]

by the following equality

\[
q(r) = \frac{n_0 kT_0}{\sqrt{\beta}} Q(r).
\]

And components of dimensionless of viscous stress tensor are connected with dimension components

\[
p_{ij}(r) = \frac{n_0 m \beta^{3/2}}{\pi^{3/2}} \int \exp(-\beta v'^2) \left( v_i' v_j' - \frac{\delta_{ij}}{3} v'^2 \right) h(r, v') d^3v',
\]

by the following equality

\[
p_{ij}(r) = \frac{mn_0}{\beta} P_{ij}(r).
\]

Let’s notice, that gas macroparameters through dimensional velocity are expressed by equalities (1.2) – (1.6), and through dimensionless velocity are expressed by equalities (1.2') – (1.6').

2. Physical sense of parameters of the equation

At first we will express parameter \( \nu \) through coefficient of self-diffusion.

Let gas consists of two identical kinds of molecules with concentrations \( n_1 \) and \( n_2 \). For simplicity we will accept, that \( n_1 \ll n_2 \). And let concentration of the first components varies along an axis \( x \). In considered conditions in linear approach the second a component will be in equilibrium with zero velocity.

For the first component the kinetic equation (1.7) will become

\[
C_x \frac{1}{n_1(x)} \frac{dn_1(x)}{dx} = -\nu \sqrt{\beta} h_1(x, C).
\]
The solution of this equation is obvious

\[ h_1(x, C) = -C_x \frac{1}{\nu \sqrt{\beta n_1(x)}} \frac{dn_1(x)}{dx}. \]

The diffusion stream \( J_x \) equals

\[
J_x = \frac{n_1}{\sqrt{\beta \pi^{3/2}}} \int e^{-C^2} C_x h_1(x, C) d^3C = -\frac{1}{2\nu \beta} \frac{dn_1(x)}{dx} = -D \frac{dn_1(x)}{dx},
\]

where \( D \) is the self-diffusion coefficient

\[ D = \frac{1}{2\nu \beta} = \frac{kT}{m\nu}. \]

Hence, the parameter \( \nu \) is defined by the equation

\[ \nu = \frac{kT}{mD}. \tag{2.1} \]

Let’s pass to finding the parameter \( \omega \). Let’s consider viscosity of one-atomic gas. Let there is a gradient of \( y \)-components of mass gas velocity \( u_y(x) \) along an axis \( x \). Then from the equation (1.7) we receive

\[
2 \sqrt{\beta} C_x C_y \frac{du_y(x)}{dx} = \nu \sqrt{\beta} (-h(x, C) + 2\omega C_x C_y P_{xy}).
\]

From here we find

\[ h(x, C) = 2(-\frac{1}{\nu} C_x C_y \frac{du_y(x)}{dx} + \omega C_x C_y P_{xy}), \]

where

\[ P_{xy} = \frac{1}{\pi^{3/2}} \int \exp(-C^2) C_x C_y h(x, C) d^3C, \]

or, in explicit form,

\[
P_{xy} = \frac{2}{\pi^{3/2}} \int \exp(-C^2)(-\frac{1}{\nu} C_x C_y \frac{du_y(x)}{dx} + \omega C_x C_y P_{xy}) C_x C_y d^3C.
\]

From last equation we find

\[ P_{xy} = -\frac{1}{2 - \omega \nu} \frac{1}{dx}. \]
Therefore, the function $h$ is constructed

$$h(x, C) = -2 \left(1 + \frac{\omega}{2 - \omega}\right) C x C y \frac{1}{\nu} \frac{du_y(x)}{dx}.$$

The dimension stream of momentum $p_{xy}$ equals

$$p_{xy} = \frac{mn}{\beta} P_{xy} = \frac{mn}{\beta} \frac{1}{\pi^{3/2}} \int \exp(-C^2) C x C y h(x, C) d^3 C,$$

or

$$p_{xy} = -\frac{k T n}{\nu} \frac{1}{2 - \omega} \frac{du_y(x)}{dx} = -\eta \frac{du_y(x)}{dx}.$$

From here we find dynamic viscosity of gas

$$\eta = \frac{k T n}{\nu} \frac{2}{2 - \omega}. \quad (2.2)$$

Kinematic viscosity is equal

$$\nu_* = \frac{\eta}{\rho} = \frac{k T}{m \nu} \frac{2}{2 - \omega} = \frac{2D}{2 - \omega}. \quad (2.2')$$

Thus, the parameter $\omega$ is defined by the equation (2.2) or (2.2'):

$$\omega = 2 \left(1 - \frac{\rho}{\eta} D\right) = 2 \left(1 - \frac{D}{\nu_*}\right). \quad (2.3)$$

Now we will find parameter $\gamma$. Let's consider now heat conductivity process. Let in gas there is a constant gradient of temperature

$$K_T = \frac{d T}{d z} = \text{const}.$$

Then the equation (1.7) transforms to the form

$$C_z \frac{d \ln T}{d z} \left(C^2 - \frac{5}{2}\right) = \nu \sqrt{\beta} \left[\gamma \left(C^2 - \frac{5}{2}\right) Q_z C_z - h(x, C)\right], \quad (2.4)$$

where $Q(r)$ is the dimensionless vector of heat stream,

$$Q(r) = \frac{1}{\pi^{3/2}} \int \exp(-C^2) C \left(C^2 - \frac{5}{2}\right) h(r, C) d^3 C.$$
Multiplying the equation (2.4) on
\[ \frac{1}{\pi^{3/2}} C_z \left(C^2 - \frac{5}{2}\right) \exp(-C^2) \]
and integrating, we receive
\[ \frac{5}{4} \frac{d \ln T}{dz} = \nu \sqrt{\beta} \left(\frac{5}{4} \gamma - 1\right) Q_z. \]

The vector of a heat stream is connected with a temperature gradient by equality
\[ q_z = -\frac{d T}{d z}, \]
where \( \kappa \) is the coefficient of heat conductivity of gas,

\[ q_x(x) = \frac{n_0}{\pi^{3/2}} \int \exp(-C^2) v_x \left(\frac{mv^2}{2} - \frac{5kT_0}{2}\right) h(x, C) d^3C = \]
\[ = \frac{n_0 kT_0}{\sqrt{\beta}} Q_x(x). \]

From last equalities we receive
\[ \frac{5}{4} \frac{d \ln T}{dz} = \nu \sqrt{\beta} \left(\frac{5}{4} \gamma - 1\right) Q_z = \frac{\nu \beta}{nkT} \left(\frac{5}{4} \gamma - 1\right) q_z = \]
\[ = -\frac{\nu \beta}{nkT} \left(\frac{5}{4} \gamma - 1\right) \kappa \frac{d T}{d z}. \]

Whence we find
\[ \kappa = -\frac{5}{4 \nu \beta \left(\frac{5}{4} \gamma - 1\right)} = \frac{nk}{\nu \beta \left(\frac{5}{4} \gamma - 1\right)}. \tag{2.5} \]

On the basis of (2.5) Prandtl’s number for the equation (1.7) is equal
\[ \text{Pr} = \frac{5}{4 \beta T} \kappa = -\frac{5}{4 \beta T} kTn \frac{\nu}{2 - \omega} \frac{4 \nu \beta \left(\frac{5}{4} \gamma - 1\right)}{nk} \]
\[ = -\frac{5 \gamma/2 + 2}{2 - \omega}. \]

From last equation we find parameter \( \gamma \)
\[ \gamma = \frac{4}{5} \left[1 - \left(\frac{1 - \omega}{2}\right) \text{Pr}\right], \tag{2.6} \]
or
\[ \gamma = \frac{4}{5} \left( 1 - \frac{D}{\nu^*} \text{Pr} \right). \]

So, equation parameters \( \nu, \gamma, \omega \) are expressed by equations (2.1), (2.3) and (2.6).

If we enter Ferziger’s number \( \text{Fe} = \frac{D}{\nu^*} \), then relations (2.6) and (2.3) can be copied in the form
\[ \gamma = \frac{4}{5} \left( 1 - \text{PrFe} \right), \]
\[ \omega = 2 \left( 1 - \text{Fe} \right). \]

Dependence of parameter \( \gamma \) from \( \omega \) represents the straight line laying in second octant (fig. 1 see). At change parameter \( \omega \) on range \([2(1 - 1/\text{Pr}), 0]\) parameter \( \gamma \) runs the range \([0, 0.8(1 - \text{Pr})]\).
Fig. 1. Segment on straight line $\gamma = 0.8[1 - \Pr(2 - \omega)/2]$, on which Prandtl's number has constant value.
4. Expression of parameters of the equation through integral brackets

Parametres of the kinetic equation we will express through the integral brackets [9] in the first and the second approximations. As the second approximation we will use approach of Kihara.

The self-diffusion coefficient is expressed through gas parameters in the first approximation as follows [9].

\[
D^{(1)} = \frac{3}{8nm} \sqrt{\pi mkT} \cdot \frac{1}{\Omega^{(1,1)*}}. \tag{4.1}
\]

In the second approximation for self-diffusion coefficient we have

\[
D^{(2)} = D^{(1)} \left[ 1 + \frac{(6C^* - 5)^2}{40 + 32A^*} \right]. \tag{4.2}
\]

In expressions (4.1) and (4.2) the following standard designations are accepted [9]

\[
A^* = \frac{\Omega^{(2,2)*}}{\Omega^{(1,1)*}}, \quad C^* = \frac{\Omega^{(1,2)*}}{\Omega^{(1,1)*}},
\]

Here

\[
\Omega^{(i,j)*} = \frac{\Omega^{(i,j)}}{[\Omega^{(i,j)}]_{r.s.}}.
\]

Here the denominator represents \( \Omega \)-integral for model molecules – rigid spheres.

Equalities (4.1) and (4.2) give the chance to express the effective collisions frequency in the first and the second approximation through \( \Omega \)-integrals. According to (2.1) we have

\[
\nu^{(1)} = \frac{kT}{m} \cdot \frac{1}{D^{(1)}} = \frac{8}{3} \sqrt{\pi} \sigma^2 n \sqrt{\frac{kT}{m} \Omega^{(1,1)*}} \tag{4.3}
\]

and

\[
\nu^{(2)} = \frac{kT}{m} \cdot \frac{1}{D^{(2)}} = \nu^{(1)} \left[ 1 + \frac{(6C^* - 5)^2}{40 + 32A^*} \right]^{-1}. \tag{4.4}
\]
As the first approximation coefficient of self-diffusion and dynamic viscosity of gas are connected by the relation

$$\frac{\rho}{\eta^{(1)}} D^{(1)} = \frac{6}{5} A^*.$$  \hfill (4.5)

On the basis of (4.5) it is found dynamic viscosity of gas in the first approximation (see [9])

$$\eta^{(1)} = \frac{5}{16} \sqrt{\pi m k T} \cdot \frac{1}{\Omega^{(2,2)*}}.$$  \hfill (4.6)

The second approximation of dynamic viscosity is equal

$$\eta^{(2)} = \eta^{(1)} \left[ 1 + \frac{3}{49} \left( \frac{\Omega^{(2,3)}}{\Omega^{(2,2)}} - \frac{7}{2} \right)^2 \right].$$  \hfill (4.7)

On the basis of (4.6) and (4.7) it is found kinematic viscosity in the first and the second approximation

$$\nu^{(1)*} = \frac{\eta^{(1)}}{\rho} = \frac{5 D^{(1)}}{6 A^*} = \frac{5}{16} \sqrt{\frac{\pi k T}{mn^2}} \frac{1}{\pi \sigma^2} \cdot \frac{1}{\Omega^{(2,2)*}}.$$  \hfill (4.8)

and

$$\nu^{(2)*} = \frac{\eta^{(2)}}{\rho} = \frac{\eta^{(1)}}{\rho} \left[ 1 + \frac{3}{49} \left( \frac{\Omega^{(2,3)}}{\Omega^{(2,2)}} - \frac{7}{2} \right)^2 \right] =$$

$$= \nu^{(1)*} \left[ 1 + \frac{3}{49} \left( \frac{\Omega^{(2,3)}}{\Omega^{(2,2)}} - \frac{7}{2} \right)^2 \right].$$  \hfill (4.9)

Let’s find the Ferziger’s number. As the first approximation Ferziger’s number on the basis of (4.1) and (4.8) it is equal

$$Fe^{(1)} = \frac{D^{(1)}}{\nu^{(1)*}} = \rho \frac{D^{(1)}}{\eta^{(1)}} = \frac{6}{5} A^* = \frac{6 \Omega^{(2,2)*}}{5 \Omega^{(1,1)*}}.$$  \hfill (4.10)

The Ferziger’s number on the basis of (4.9) in the second approach is equal
\[ \text{Fe}^{(2)} = \text{Fe}^{(1)} \cdot \frac{1 + \frac{(6C^* - 5)^2}{40 + 32A^*}}{1 + \frac{3}{49} \left( \frac{\Omega^{(2,3)}}{\Omega^{(2,2)}} - \frac{7}{2} \right)^2}. \]

Let us consider the Prandtl number. For this purpose it is required heat conductivity of gas in the first and the second approximations. Heat conductivity as a first approximation looks like (see [9])

\[ \kappa^{(1)} = \frac{25 \sqrt{\pi mkT}}{32 \frac{\pi \sigma^2}{c_v}} \cdot \frac{1}{\Omega^{(2,2)*}}. \]

and in second approximation

\[ \kappa^{(2)} = \kappa^{(1)} \left[ 1 + \frac{2}{21} \left( \frac{\Omega^{(2,3)}}{\Omega^{(2,2)}} - \frac{7}{2} \right)^2 \right]. \]

For the first approach it is received

\[ \text{Pr}^{(1)} = \frac{5}{4\beta T} \cdot \frac{\eta^{(1)}}{\kappa^{(1)}} = \frac{2}{3}, \]

and in second approximation

\[ \text{Pr}^{(2)} = \frac{5}{4\beta T} \cdot \frac{\eta^{(2)}}{\kappa^{(2)}} = \frac{2}{3} \cdot \frac{1 + \frac{3}{49} \left( \frac{\Omega^{(2,3)}}{\Omega^{(2,2)}} - \frac{7}{2} \right)^2}{1 + \frac{2}{21} \left( \frac{\Omega^{(2,3)}}{\Omega^{(2,2)}} - \frac{7}{2} \right)^2}. \]

Let’s remind, that for model molecules – rigid spheres [9]

\[ [\Omega^{(l,r)}]_{r.s.} = \left( \frac{kT}{\pi m} \right)^{1/2} \frac{(r + 1)!}{2} \left[ 1 - \frac{1 + (-1)^l}{2(l + 1)} \right] \pi \sigma^2. \]

Let us write out expressions for kinetic coefficient in case of the gas consisting from molecules - rigid spheres. We will notice, that according to definition

\[ A^* = 1, \quad C^* = 1. \]

Self-diffusion coefficient in the first and second approach it is equal accordingly
\[ D^{(1)} = \frac{3}{8nm} \sqrt{\frac{\pi mkT}{\pi \sigma^2}}, \quad D^{(2)} = D^{(1)} \cdot 1.01388(8). \]

Hence, for effective collisions frequency in the first and the second approximations it is received

\[ \nu^{(1)} = \frac{8}{3} \sqrt{\pi \sigma^2 n} \sqrt{\frac{kT}{m}}, \quad \nu^{(2)} = \nu^{(1)} \cdot 0.986301. \]

Dynamic viscosity of gas in the first and the second approximations it is equal accordingly

\[ \eta^{(1)} = \frac{5}{16} \sqrt{\frac{\pi mkT}{\pi \sigma^2}}, \quad \eta^{(2)} = \eta^{(1)} \cdot 1.015306. \]

Kinematic viscosity of gas in the first and the second approximations it is equal accordingly

\[ \nu^{*^{(1)}} = \frac{\eta^{(1)}}{\rho} = \frac{5D^{(1)}}{6A^*} = \frac{5}{16} \sqrt{\frac{\pi kT}{mn^2}} \frac{1}{\pi \sigma^2}, \quad \nu^{*^{(2)}} = \nu^{*^{(1)}} \cdot 1.015306. \]

The Ferziger’s number in the first and the second approximations accordingly equals

\[ Fe^{(1)} = \frac{6}{5}, \quad Fe^{(2)} = Fe^{(1)} \cdot 0.998604. \]

Prandtl number in the first and the second approximations is equal accordingly

\[ Pr^{(1)} = \frac{\nu^{(1)}}{\nu^{*^{(1)}}} = \frac{2}{3} = 0.66666(6), \quad Pr^{(2)} = \frac{\nu^{(2)}}{\nu^{*^{(2)}}} = \frac{2}{3} \cdot 0.991694 = 0.661129. \]

For comparison we will write the expression of Prandtl number calculated according by the Chapman—Enskog method: \( Pr = \frac{2}{3} \cdot 0.990109 = 0.660073 \). Distinction between Prandtl number, calculated according by Kihara method and Chapman—Enskog method, makes 0.16 \%. 

3. Conclusion

In the present work the linear kinetic Holway–Shakhov equation for the rarefied one-atomic gas is constructed.

This equation contains the members describing the relative change of numerical density of gas, mass velocity of gas, relative change of temperature of gas, heat stream in gas and viscous stress tensor.

Numerical parameters of this equation are expressed through coefficient of self-diffusion, kinematic (or dynamic) viscosity of gas and heat conductivity. Then these quantities are expressed through integral brackets.

Further authors purpose to present the analytical solution of classical problems of the kinetic theory such as the Kramers’ problems about isothermal sliding, the Maxwell problems about heat sliding, the Smoluchovsky problems about temperature jump and weak evaporation.
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