Features of the rarefied gas description in terms of a distribution function

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Abstract. The aim of the paper is to determine the relationship of the classical model for describing a rarefied gas using the distribution function and its discrete representation. Here we study the role of discreteness in the description of a medium in the kinetic theory and the interrelation between interaction of the discreteness and the “continuity” of a media. The question of the relationship between the discreteness of a medium and its description with the help of continuum mechanics is important both when processing experimental data and when going from a continuum model to discrete one in mechanics and physics. There are many studies devoted to the influence of the transition from a continuous to discrete medium in computational mathematics, but there is no study of inverse processes. The work related to the formulation of conservation laws as conditions of the equilibrium of forces and moments of forces, as well as the action of additional flows on the sides of an elementary volume, was carried out earlier. After refinement, non-symmetric stress tensor was obtained. The method for calculating this tensor was proposed. The equations for a gas were found from the modified Boltzmann equation and from the phenomenological theory. Inaccuracy leading to the symmetry of the stress tensor arises when calculating the Lagrange function of particles as the sum of pairwise interacting particles and the unchanged position of the inertia system center.

1. Introduction

The conservation laws are based on experimental data obtained for finite elementary volumes. Physical quantities can be also determined either in terms of delta functions or by going to infinitely small limit of the ratio the determined quantity to the volume (surface element, etc.). In the first case, we have a discrete representation; in the second, a continuous one. The main method for determining physical quantities in a rarefied gas is the approximation of a discrete quantity by a continuous distribution function. Determining the relationship of the classical model for describing a rarefied gas using the distribution function with its discrete representation is the goal of the paper. The question of the relationship between the discreteness of a medium and its description with the help of continuum mechanics arises due to the fact that the distances between molecules in a rarefied gas are finite, the times between collisions are finite, but on definition when calculating derivatives in time and space we deal with infinitely small value. To lean the kinetic theory, which gives the same results as continuum mechanics, we can’t due to the underlying provisions that are in. Namely, the Boltzmann equation does not fulfill one of the laws of mechanics - the law of conservation of angular momentum. At first, relaxation problems were considered, but later the theory was transferred without changes to
weakly and strongly nonequilibrium processes. In Hilbert’s hypothesis, it is assumed that the values of macroparameters can be calculated from the zero approximation for the equilibrium distribution function. In all works, including those of N.N. Bogolyubov [1], this hypothesis is the basis of the theory. Consequently, according to the hypothesis, the values for the equilibrium distribution function with the macroparameters found from the Euler equations and the Navier Stokes equations are the same. As we know, the differences are significant in domains with large gradients. Any equilibrium distribution function ensures the symmetry of the stress tensor. This result follows from the choice of equilibrium conditions for forces as the conditions of an equilibrium for elementary volume. The choice of the equilibrium condition for the moments of forces with the simultaneous condition of the equilibrium for forces leads to new formulations of the equations [2-8]. Consequently, under the condition of the equilibrium of forces, we arrive at a particular classical formulation of continuum mechanics. The resulting formulation of the conservation laws is associated with recording the conservation laws for a system that exchanges the components of physical quantities only by means of a convective velocity directed along the normal to the surface and ignoring any processes within the elementary volume, as well as ignoring the exchange through the tangent component. In the classical approach, the conservation law for angular momentum in nonequilibrium process is not built. The symmetry of the stress tensor leads to a violation of the "continuity" of the medium. Therefore, it is required to provide coordination conditions [9, 10], which, as a rule, are not done in computational mechanics. This paper is devoted to the analysis of the mathematical aspects of the theory.

2. Analysis of the mathematical model

At the molecular level, it is customary to equally consider the Lagrange function for non-interacting and for collectively interacting particles. This is in doubt, especially for molecules with metallic and ionic couplings. The disadvantage of the adopted model is in ignoring the movement of the inertia axis of the elementary volume during any movement of molecules. The motion of the inertia axis gives rise to an angular momentum, that is, extra strings arise. However, the laws of Newton are worked. Consequently, the additional force will give sum with the acting force and will change the velocity of movement of individual molecules and their combination. Under an arbitrary position of an elementary volume, the coordinate axes are often not parallel to the sides of the elementary volume and, moreover, to the directions of velocity. Consequently, the tangential component will also give the normal velocity component [11]. As a result,

$$\frac{\partial \rho}{\partial t} + \frac{\partial ((\rho u) \cdot n + (\rho u) \cdot \tau)}{\partial x_i} = 0$$

In addition, to obtain a differential equation, we take the integral in parts. After that, we discard the term that is out of integral, which in the case of non-symmetric motion will give circulation velocity. This is most clearly seen in the two-dimensional case

$$\frac{\partial}{\partial t} \int_\tau \rho \delta \tau + \int_\sigma \rho V_n \delta \sigma = \int_\tau \dot{M} \delta \tau$$

Recall the Ostrogradsky-Gauss formula

$$\iiint_v \left( \frac{\partial P}{\partial x} + \frac{\partial Q}{\partial y} + \frac{\partial R}{\partial z} \right) \, dv = \iint_s \left[ P \cos(n, x) + Q \cos(n, y) + R \cos(n, z) \right] \, ds,$$

$$\int_0^1 (P \, dx + Q \, dy + R \, dz) = \iint_s \left[ \left( \frac{\partial R}{\partial y} - \frac{\partial Q}{\partial z} \right) \cos(n, x) + \left( \frac{\partial P}{\partial z} - \frac{\partial R}{\partial x} \right) \cos(n, y) + \left( \frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y} \right) \cos(n, z) \right] \, ds,$$

Here $\rho$ is the density, $u$ is the velocity, $n$ is the normal, $\tau$ is the ort of the tangent, $\sigma$ is the elementary volume, $P, Q, R$ are the flows through the corresponding sides, $\cos(n, x), \cos(n, y)$,
$\cos(n, z)$ – are the direction cosines of the angles, $s$ is an element of the surface. This factor is responsible for the appearance of additional terms in the equations of S.V. Vallander [12, 13] even in the absence of contributions of angular momentum. These terms represent diffusion effects. For us it is important about the elementary volume that when gas move it additionally can either rotate around the axis of inertia or be involved in the rotational motion. In either case, the density flux through the boundary changes by $\frac{d\rho}{dt} \cdot (r' - r) + \cdots$ due to the rotation of the elementary volume. We have no reason to change the classical equation of motion (and the projections of this equation), but the symmetry of the stress tensor does not follow from the classical conclusion. From a phenomenological conclusion, the system must be supplemented by the laws of conservation of angular momentum. The latter serve to determine the degree of not symmetry of the stress tensor. The equations are known, but our interpretation is different. The specific form is obtained from the modified Boltzmann equation with accounting of influence symmetry of the stress tensor. The equations are known, but our interpretation is different. The basis of this interpretation is the change in the Lagrange function. A change in the Lagrange function led to a change in the Liouville equation and the laws of conservation of angular momentum. The latter were associated with a change in the position of the axis of inertia of the elementary volume. We have no reason to change the classical equation of motion (and the projections of this equation), but the symmetry of the stress tensor does not follow from the classical conclusion. From a phenomenological conclusion, the system must be supplemented by the laws of conservation of angular momentum. The latter serve to determine the degree of not symmetry of the stress tensor. The equations are known, but our interpretation is different. The specific form is obtained from the modified Boltzmann equation with accounting of influence the angular momentum. The basis of this interpretation is the change in the Lagrange function associated with a change in the position of the axis of inertia of the elementary volume

$$ \frac{dL}{dt} = \sum_i \left[ \frac{\partial L}{\partial \dot{q}_i} \dot{q}_i + \frac{\partial L}{\partial \dot{q}_i} \ddot{q}_i \right] + \sum_i \left[ \frac{\partial L}{\partial (q_i - a)} (\dot{q}_i - \dot{a}) + \frac{\partial L}{\partial (\dot{q}_i - \dot{a})} (\ddot{q}_i - \ddot{a}) \right], $$

$a = \sum_i m_i v_i^2$. In classical case $L = \sum_i \frac{m_i v_i^2}{2} - U(r_1, r_2, \ldots)$. $U(r_1, r_2, \ldots)$ – full potential of interaction of all particles, but in practice these are usually known interaction potentials of two particles, and we use their sum. For equilibrium or with small deformations, this works well, but with non-equilibrium thermodynamic effects and disturbances lead to an uneven distribution of physical parameters and the role of collective effects, determined by the growing influence of angular momentum. For example, for interacting charged particles $a = \sum_i \frac{e_i r_i}{|r_i|}$.

A change in the Lagrange function led to a change in the Liouville equation and the N.N. Bogolyubov [1] equation. Boltzmann equation and conservation laws. The latter were obtained from the equations, taking into account the angular momentum in [2–8]

$$ \rho \left( \frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} + w \frac{\partial u}{\partial z} \right) = \rho F_x + \frac{\partial P_{xx}}{\partial x} + \frac{\partial P_{yx}}{\partial y} + \frac{\partial P_{zx}}{\partial z}, $$

$$ \rho \left( \frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} + w \frac{\partial v}{\partial z} \right) = \rho F_y + \frac{\partial P_{xy}}{\partial x} + \frac{\partial P_{yy}}{\partial y} + \frac{\partial P_{zy}}{\partial z}, $$

$$ \rho \left( \frac{\partial w}{\partial t} + u \frac{\partial w}{\partial x} + v \frac{\partial w}{\partial y} + w \frac{\partial w}{\partial z} \right) = \rho F_z + \frac{\partial P_{xz}}{\partial x} + \frac{\partial P_{yz}}{\partial y} + \frac{\partial P_{zz}}{\partial z}, $$

$$ y \left( \frac{\partial \sigma_{zx}}{\partial x} + \frac{\partial \sigma_{yz}}{\partial y} + \frac{\partial \sigma_{zy}}{\partial z} \right) - z \left( \frac{\partial \sigma_{xy}}{\partial x} + \frac{\partial \sigma_{yx}}{\partial y} + \frac{\partial \sigma_{yz}}{\partial z} \right) + \sigma_{zy} - \sigma_{yz} = 0, $$

$$ x \left( \frac{\partial \sigma_{xy}}{\partial x} + \frac{\partial \sigma_{yx}}{\partial y} + \frac{\partial \sigma_{yy}}{\partial z} \right) - y \left( \frac{\partial \sigma_{xx}}{\partial x} + \frac{\partial \sigma_{xy}}{\partial y} + \frac{\partial \sigma_{yy}}{\partial z} \right) + \sigma_{yx} - \sigma_{xy} = 0, $$

$$ x \left( \frac{\partial \sigma_{xz}}{\partial x} + \frac{\partial \sigma_{yz}}{\partial y} + \frac{\partial \sigma_{zx}}{\partial z} \right) - z \left( \frac{\partial \sigma_{xx}}{\partial x} + \frac{\partial \sigma_{yx}}{\partial y} + \frac{\partial \sigma_{zx}}{\partial z} \right) + \sigma_{zx} - \sigma_{xz} = 0. $$

The equations of state remain the same. As a result, higher-order equations are obtained for velocities. Therefore, there is a need for setting boundary conditions. For boundary layer problems, vorticity can be specified.
3. The problem of relaxation in a rarefied gas

The correspondence of a continuous description to a discrete one and back is a fundamental problem of modern science. The transition from continuous to discrete description has been studied in many works on computational mathematics [14, 15], on inverse transformation is not given due attention, although it is important for studying phenomena associated with finite distances between molecules, particles in multiphase systems, etc. It is interesting to compare derivatives for discrete and continuous descriptions. First, we consider the relaxation process (in time) without flows through the boundaries \( f = f(\mathbf{r}(t), \xi(t)) \). Let the distribution function is represented as

\[
  f = \sum_{i=1}^{n} \frac{\delta(\mathbf{r}_i - \mathbf{r})}{\sum_{i=1}^{N} \delta(\mathbf{r}_i - \mathbf{r})},
\]

that is \( f = \frac{n}{N} \), where \( n \) is the number of molecules in an elementary volume, \( N \) is the number of molecules in a perturbed volume. Then

\[
  \frac{\partial f}{\partial t}\bigg|_{t = \text{const}} = \frac{\partial}{\partial t} \left( \sum_{i=1}^{n} \delta(\mathbf{r}_i - \mathbf{r}) \right).
\]

Consider the dependency \( \delta(\mathbf{r}_i - \mathbf{r}) \) from \( t \) just like \( \mathbf{r}_i(t) - \mathbf{r}(t) \).

If there are no threads

\[
  \frac{F_1}{F_3} - \frac{F_2}{F_4} = \frac{\sum_{i=1}^{n} \delta(\mathbf{r}_i - \mathbf{r}) + \sum_{i=1}^{n} \Delta t \frac{\partial \delta(\mathbf{r}_i - \mathbf{r})}{\partial t} + \ldots}{\sum_{i=1}^{N} \delta(\mathbf{r}_i - \mathbf{r}) + \sum_{i=1}^{N} \Delta t \frac{\partial \delta(\mathbf{r}_i - \mathbf{r})}{\partial t} + \ldots} - \frac{\sum_{i=1}^{n} \delta(\mathbf{r}_i - \mathbf{r})}{\sum_{i=1}^{N} \delta(\mathbf{r}_i - \mathbf{r})} \approx \frac{\sum_{i=1}^{n} \delta(\mathbf{r}_i - \mathbf{r}) + \sum_{i=1}^{n} \Delta t \frac{\partial \delta(\mathbf{r}_i - \mathbf{r})}{\partial t} + \ldots}{\sum_{i=1}^{N} \delta(\mathbf{r}_i - \mathbf{r}) + \sum_{i=1}^{N} \Delta t \frac{\partial \delta(\mathbf{r}_i - \mathbf{r})}{\partial t} + \ldots} \approx \left( 1 - \frac{\sum_{i=1}^{N} \Delta t \frac{\partial \delta(\mathbf{r}_i - \mathbf{r})}{\partial t} + \ldots}{\sum_{i=1}^{N} \delta(\mathbf{r}_i - \mathbf{r})} \right) - \frac{\sum_{i=1}^{n} \delta(\mathbf{r}_i - \mathbf{r})}{\sum_{i=1}^{N} \delta(\mathbf{r}_i - \mathbf{r})} = \frac{\sum_{i=1}^{n} \Delta t \frac{\partial \delta(\mathbf{r}_i - \mathbf{r})}{\partial t} + \ldots}{\sum_{i=1}^{N} \delta(\mathbf{r}_i - \mathbf{r})},
\]

\[
  \frac{\partial \delta(\mathbf{r}_i - \mathbf{r})}{\partial t} - \text{thus, for a rarefied gas, when solving the Boltzmann equation, we receive the time derivative is only depends from the macroparameters. This hypothesis is used in the theory of rarefied gas in constructing a solution to the Boltzmann equation by the Chapman-Ensky method.}
\]

When accounting for flows across the border, we will have

\[
  \frac{F_1}{F_3} - \frac{F_2}{F_4} = \frac{\sum_{i=1}^{n} \delta(\mathbf{r}_i - \mathbf{r}) + \sum_{i=1}^{n} \Delta t \frac{\partial \delta(\mathbf{r}_i - \mathbf{r})}{\partial t} + \sum_{i=1}^{n} \delta(\mathbf{j}_i \mathbf{r}_i - \mathbf{r}) + \sum_{j=1}^{\Omega \mathbf{r}} \frac{\mathbf{p}_j}{m} \Delta t \frac{\partial \delta(\mathbf{r}_i - \mathbf{r})}{\partial t} + \ldots}{\sum_{i=1}^{n} \delta(\mathbf{r}_i - \mathbf{r}) + \sum_{i=1}^{n} \Delta t \frac{\partial \delta(\mathbf{r}_i - \mathbf{r})}{\partial t} + \sum_{j=1}^{\Omega \mathbf{r}} \frac{\mathbf{p}_j}{m} \delta(\mathbf{r}_i - \mathbf{r}) + \sum_{j=1}^{\Omega \mathbf{r}} \Delta t \frac{\partial \delta(\mathbf{r}_i - \mathbf{r})}{\partial t} + \ldots} - \frac{\sum_{i=1}^{n} \delta(\mathbf{r}_i - \mathbf{r})}{\sum_{i=1}^{n} \delta(\mathbf{r}_i - \mathbf{r})}.
\]

Index \( V \) – refers to the volume, \( \Omega \) – to the surface. \( \sum_{j=1}^{\Omega \mathbf{r}} \frac{\mathbf{p}_j}{m} \delta(\mathbf{r}_i - \mathbf{r}) = J_2 - J_1 \) – flow of fast molecules from neighboring cells.

Thus, the role of borders increases. The distribution function does not provide the correct parameter values. Here work only the molecular dynamics method with a very small on time step is correct.

4. Lag effects

In the kinetic theory, when considering the role of delay, one should deal with the question of what is measured in the experiment: instantaneous values or averaged values. If the experiment
deals with averages, it is important to choose the time and scale of averaging. In this case, the
delay is not necessary to take into account, except when the relaxation time and the delay time
are commensurable, otherwise the following should be kept in mind: The length of the molecules
of the \(i\)-th group relative to the molecules of the \(j\)-group is, in classical mechanics

\[
\lambda_{ij} = \frac{\xi_i}{\sigma_{ij} n_i g_{ij}}
\]

Mean free path of the molecules are

\[
\bar{\lambda} = \frac{\sum_{i,j=1}^k \xi_i n_i}{\frac{1}{2} \sum_{i,j=1}^k \sigma_{ij} n_i g_{ij}}
\]

The average velocity of the molecules

\[
\bar{g} = \frac{1}{2 n^2} \sum_{i,j=1}^k n_i n_j g_{ij}
\]

Mean time is \(\bar{\tau} = \frac{\bar{\lambda}}{\bar{g}}\)

The Boltzmann equation can be written as

\[
\frac{\partial f}{\partial t} = \frac{\partial f}{\partial t} + \frac{\partial f}{\partial r_i} + \frac{\partial f}{\partial r_j} \frac{\partial f}{\partial r_i} - \frac{F}{m} \frac{\partial f}{\partial c_i} = I,
\]

\[
\frac{\partial f}{\partial t} = \frac{\partial f}{\partial t} + \bar{\tau} \frac{\partial^2 f}{\partial t^2} + \sigma_{ij} \frac{\partial f}{\partial r_j} \frac{\partial f}{\partial r_i} - \frac{F}{m} \frac{\partial f}{\partial c_i} = I,
\]

\[
\Delta^- = dt d\vec{x} d\vec{\xi} f(t, \vec{x}, \vec{\xi}) \int \left[ f_1(t, \vec{x}, \vec{\xi} + O(\Delta t \frac{\partial f_1}{\partial x})) \right] gb db d\varepsilon d\xi_1,
\]

\[
\Delta^+ = dt d\vec{x} d\vec{\xi} \int \left[ f(t, \vec{x}, \vec{\xi}) f_1(t, \vec{x}, \vec{\xi}_1 + O(\Delta t \frac{\partial f}{\partial x})) \right] g' b' d'b' d\varepsilon' d\xi_1,
\]

\[
I = \Delta^- - \Delta^+,
\]

\[
\frac{\partial f}{\partial t} \leftrightarrow \frac{\partial f}{\partial t} + \bar{\tau} \frac{\partial^2 f}{\partial t^2},
\]

\[
f(t, x, \xi) \leftrightarrow f(t + \bar{\tau}, x + \bar{\lambda}, \xi) \leftrightarrow f(t, x, \xi) + \bar{\tau} \frac{\partial f}{\partial t} + \bar{\lambda} \frac{\partial f}{\partial x} + \cdots,
\]

\[
f_1(t, x, \xi) \leftrightarrow f_1(t + \bar{\tau}, x + \bar{\lambda}, \xi) \leftrightarrow f_1(t, x, \xi) + \bar{\tau} \frac{\partial f_1}{\partial t} + \bar{\lambda} \frac{\partial f_1}{\partial x} + \cdots.
\]

Average values are chosen in the formulas, although it is possible to calculate for individual
velocities and consider their sum. Similarly, the values with a prime (hatch) are calculated,
since the molecule need reach during the free path the another molecule, and the free path and
the mean free path of the molecules before and after the collision can be different
\((\tau, \tau', \lambda, \lambda')\), the values of incident and incident molecules may also differ (with an index of one).

\[
f f_1 - f' f'_1 \leftrightarrow f f_1 - f' f'_1 + \bar{\tau} \frac{\partial f}{\partial t} f_1 + \tau f \frac{\partial f_1}{\partial t} + \lambda f \frac{\partial f_1}{\partial x} + \cdots
\]

\[
- \tau' \frac{\partial f_1}{\partial t} f'_1 - \tau'_1 \frac{\partial f'_1}{\partial t} - \cdots - \lambda' \frac{\partial f'_1}{\partial x} f'_1 - \lambda' \frac{\partial f'_1}{\partial x} f' - \cdots.
\]
In the general case, this formula should be written out in the indicated form, but for small gradients for a simple gas, one can have one time interval and one path length. However, for structural gas, for example, at altitudes of more than 120 km, the free run time at three Mach numbers, i.e. delay time $10^{-8}$ s. and more, which can be commensurate with the relaxation time. In fact, the expression can be simplified, given the orders of magnitude. Then

$$ff_1 - f'f'_1 \leftrightarrow ff_1 - f'f'_1 + \tau \frac{\partial f^0}{\partial t} f_1^0 + \tau_1 f^0 \frac{\partial f^0}{\partial t} f_1^0 + \lambda \frac{\partial f^0}{\partial x} f_1^0 + \lambda_1 \frac{\partial f^0}{\partial x} f_1^0 + \cdots -$$

$$- \tau' \frac{\partial f^0}{\partial t} f_1^0 - \tau' f^0 \frac{\partial f^0}{\partial t} f_1^0 - \cdots - \lambda' \frac{\partial f^0}{\partial x} f_1^0 - \lambda_1' \frac{\partial f^0}{\partial x} f' - \cdots .$$

The integrals are calculated and the corresponding kernels of the Navier-Stokes equations can be found. So, for small and medium gradients, the mean free time is one and the mean free path is one for a single-component gas. Significant differences will be when considering the interaction of gases with very different properties. So for some organic molecules, the relaxation time and the lag time with average free path lengths are commensurable (approximately $10^{-8}–10^{-9}$ s). We considered the effect of the delay effect in the collision integral. But the equation also includes convective terms, i.e. derivatives. Therefore, we need to track their role. The distribution function is statistical in nature, i.e. it deals with macro values. Accordingly, as we see from the equations, with large gradients of parameters, the flow terms play a large role and they determine the delay or advance of fast molecules of the mean flow. When the temperature rises, it is important to correctly take into account the composition of the gas, which is a mixture of various components. The formulas currently used are obtained with small values of additives. Here a new formulation is proposed for determining pressure, temperature and energy. Common wording [16-21]

$$\frac{3}{2} KT = \frac{1}{n} \sum \int \frac{m_k c_k^2}{2} f_k d\xi_k, \quad (n = \sum_{k=1}^{N} n_k)$$

Here $k$ – number of components, $T$ – temperature, $c_k = \xi_k - u$, ones velocity of molecules, $\xi_k$ velocity of molecules. Another definition is

$$\frac{3}{2} KT = \int \left( \sum \frac{n_k m_k}{n} c_k \right) \left( \sum \frac{n_k m_k}{n} c_k \right) f d\xi$$

Then we have one term is traditional and another is as the second viscosity. For stress tensor we can have

$$P_{ij} = \int \left( \sum \frac{n_k m_k c_k}{n} \right) \left( \sum \frac{n_k m_k c_k}{n} \right) f d\xi$$

For the flux of the heat

$$q = \int \left( \sum \frac{n_k m_k c_k}{n} \right) \left( \sum \frac{n_k m_k}{n} \right) \left( \sum \frac{n_k m_k c_k}{n} \right) / 2 f d\xi$$

What we take in experiment?

$$f_v^{(0)} = n^v \left( \frac{m}{2\pi kT} \right)^{3/2} \exp \left( - \frac{m}{2kT} c^v \right)$$

or for exclusive temperature

$$f_v^{(0)} = n^v \left( \frac{m}{2\pi kTv} \right)^{3/2} \exp \left( - \frac{m}{2kT} c^v \right)$$

For full temperature we cannot conclude the right probability. Old formulas remain for internal energy, but the definition of temperature changes.
5. Conclusion
The paper proposes a refinement of the equations of continuum mechanics that consistent with classical theoretical mechanics, taking into account the angular momentum and delay, as well as the position of the center of inertia of the elementary volume. The possibility of describing discrete media within the framework of continuum mechanics is analyzed. The discarded physical effects resulting from the replacement of a discrete medium of a rarefied gas with a finite mean free paths and with a finite distance between molecules by the distribution function are analyzed. The role of dispersion and delay in the physicochemical processes of relaxation type is established. The hypotheses of the kinetic theory leading to the symmetry of the stress tensor are investigated.

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