

## FROM ANCIENT ATOMISM TO FIRST KINETIC THEORIES OF GASES

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**Abstract:** *Starting from ancient atomism and traditional scientific atomism, there is an analytical study of the development of kinetic gas theory in the 18th century. In particular, it is described the development of two main ideas, which underpinned the first formulations of this theory: the hypotheses regarding the internal structure of the matter and the speculations about the material nature of the heat and the first theories formulated by Jakob Hermann and Leonhard Euler. It is shown that the first quantitative formulation of this theory was given by Daniel Bernoulli, who explicitly determined the kinetic origin of pressure and temperature. In the eighteenth century, Bernoulli's kinetic theory was not taken seriously, but neither the theories developed by Lomonosov and Boscovich were successful. In this way, the causes that led to the stagnation of the kinetic theory of gases in the second half of the 18th century were highlighted.*

**Keywords:** *Atomism, gas theories, kinetic theories*

### 1. Introduction

Being one of the most solid bases of the modern science, the kinetic-molecular theory of gases is defined nowadays as a branch of molecular physics, that has as object of study gases' macroscopic behavior depending on the characteristics of the constituent molecules movement. Due to the knowledge of this relationship, many physical phenomena from gaseous, liquid and even solid media can find a simple and convincing explanation in the kinetic theory. It is known, for example, that the pressure exerted by a gas on the vessel's walls it comes into contact with is the result of multiple collisions of moving molecules, resulting in transmission of its quantity of motion. Its variation in the time unit leads, according to impulse's first theorem – the theorem of quantity of motion – to the appearance of an external force, that being divided on the unit of area of the wall's surface is indeed the pressure. The pressure thus defined is called kinetic pressure. The kinetic energy of the particles, averaged on a very big number, determines exactly what we call the temperature of the substance.

### 2. Problem formulation

Numerous studies have been sanctioned to the development of the kinetic molecular theory of gases in the early period, that have contributed to the correct understanding of the concepts and ideas formulated by the creators of this theory throughout history. However, up till now not a unitary approach of treating the historical process of scientific bases formation of the kinetic theory of gases has been imposed, and some aspects of the subject continue even nowadays to bother our scientific communities. Almost nothing is known about first theories formulated by Hermann, Euler, Bernoulli, Lomonosov and Boscovich. The same thing can be said about both the ancient atomism as well as the scientific atomism from the 17th century.

Considering the mentioned above, an analytical study of the kinetic theory of gases development in 18th century is performed in the following work, preceded by a short analysis of atomistic theory in the ancient philosophy and scientific atomism from the 17th century. In particular, it aims to develop two main ideas that underpinned the first wording of this theory, namely the hypotheses regarding the internal structure of the substance and the speculations about material heat.

### 3. The atomistic theory in ancient philosophy

The origins of the kinetic theory of gases are found in the ancient atomism, a theory that would have exerted an overwhelming influence on later science and technics. Right from the beginning the atomistic theory has been asserted as a philosophical stream, based on the idea that the substance has a discrete structure, the constituent particles, the atoms, being indivisible and eternal [1]. It seems that this theory has been created by the Phoenician philosopher *Mochus from Sidon* before the Trojan wars [2], that is in 14th century before Christ. The father of modern chemistry, Robert Boyle, advocates that in the past scientists were attributing the elaboration of the atomic hypothesis to a certain Mochus from Sidon. Isaac Newton was on similar positions. Indian philosophers *Uluka* (7th century B.C.) and *Acharya Kanad* (6th century B.C.) have talked about atoms and molecules, who were considering the objects as made of atoms bonded between them to form the molecules [1].

In the Western philosophy the ancient atomism is associated with the name of the Greek pre-Socratic philosopher *Leucippus from Miletus* (approx. 500-450 B.C.), that created his theory around the year 475 B.C. [1-3]. Based on Leucippus, the Universe is composed of an empty space and an infinitely large number of small and indivisible particles, called atoms. In Leucippus atomistic theory, the formation of the world and its different things was based on the join property of immortal atoms but not on the existence of a natural superpower. It was undoubtedly the first step made by a scientist on the path of materialistic understanding of the world.

But would there had been at that moment any relationship between Indian and Greek atomism? The only country where the Greeks could take over from the ideas of atomism in the 5th century B.C. was undoubtedly India. But this isn't exactly known to the modern science.

The atomistic theory has been further developed and founded by *Democritus from Abdera* (approx. 460-370 B.C.), the most important materialist philosopher of the ancient world [1-3]. A general image regarding Democritus' atomistic theory can be made out of the next quote very frequently used [3]: „*It doesn't exist anything else rather than atoms and empty space, everything else is opinion. Only in the general opinion the color exists, in opinion the sweet, in opinion the bitter..., but in reality exist only atoms and void*”. The atoms were imagined by the great thinker as some solid, indivisible and of different sizes particles, that are in a continuous motion and eternal, from time perspective. According to Democritus, the atoms weren't deformable. Besides these physical properties, the atoms were having different geometrical shapes, that's the explanation of their possibility of combining each other to form the reality and all the physical bodies from the Universe. Democritus is reasoning on this idea [3]: „*The atoms are infinite and infinitely variable in shape. The variety of all the things depends on the variety of constituent atoms as number, dimension and state of motion*”. By the ways of atoms joining and motion is explained the variety of phenomena from nature. So, moving initially in all the possible directions the atoms are colliding between them forming vortices, that give birth to countless worlds in the infinite void. The atoms' chaotic motion in all the directions lies at the heart of everything that is happening in the great world, whose phenomena don't resemble nevertheless the motion of the atoms in void.

Although Democritus theory has nothing in common with actual understanding of the nature, however, we shouldn't be too exigent toward the ancient atomism, because as the science historian George Sarton is warning us [4]: „*When judging the Greek atomic theory we have to protect ourselves against two temptations: first is the one of equalizing it with the modern theory invented by Dalton at the beginning of 19th century; second is the one of not including it in the history of science by virtue of its confusion. Certainly, there is a huge difference between the Greek and Dalton's idea: there's a big difference between a philosophical concept, that can't be checked, and a scientific hypothesis, that invites to a long series of experimental checks. On the other hand, there is no doubt that Democritus' theory, resurrected by Epicurus and popularized by Lucretius, has been an intellectual incentive for centuries. The Jewish and Christian professors have tried to sink it, but it has never died*”. The atomistic theory has maintained itself „*through out the entire classical period, as a steadfast heresy*” [5], marking both the evolution of the materialistic philosophy about the world and life, as well as the development of natural sciences.

But, on the other hand, it would be an enormous error to consider the ancient atomism a scientific theory of physics. This idea results from the simple reason that no affirmation of the Greek atomistic philosophy could be proven experimentally. However, Democritus and Epicurus conceptions have served as a source of inspiration for a period of more than 2500 years, a reason why the atomism from ancient Greece is considered nowadays „*the direct and recognized ancestor of all the modern atomic theories*” [5].

#### 4. The traditional scientific atomism

The technical and scientific progress from the first half of 17th century has substantially contributed to the revival of the atomistic theory of ancient Greeks. Among the animators of traditional atomism, we can find notorious names of worldwide science and philosophy, like Nicolaus Copernicus in Poland, Giordano Bruno and Galileo Galilei in Italy, Isaac Newton, Francis Bacon and Thomas Hobbes in England, but also less known names, like the ones of Daniel Sennert in Germany and Claude Guillermet de Bérigard in France, who have opted for the reconciliation of Aristotle's physics with Democritus' atomism. However, the great figures of the revival of atomism in this period were René Descartes, Pierre Gassendi and Robert Boyle.

The famous French mathematician, physicist and philosopher *René Descartes* (1596-1650) was not recognizing the atomistic conceptions of ancient and medieval philosophy [1, 6]. In contrast to then existing atomistic theory, he has developed his own corpuscular theory, known under the name of the doctrine of the full space. As it's known, Descartes has shown a special interest in Torricelli's void, although has vehemently denied its existence in nature. In the doctrine of the full space, elaborated in 1630, the emphasis has been placed on the simple expansion and the full and continuous filling of the Universe with subtle matter, powered through impulse transmitted from one place to another. In the 17th century, Descartes' theory didn't have a quantitative basis, even though was supported from a qualitative point of view by the widespread idea that the heat is closely related to the motion of the atoms, but the air pressure increases together with the temperature. Later, the Cartesian physics has been severely criticized by Isaac Newton.

Relying on the atomistic conceptions of Epicurus and Lucretius and also on the achievements of the physics of those times, the Provençal priest *Pierre Gassendi* (1592-1655), one of the greatest astronomers, mathematicians and philosophers of his time, in contrast to Descartes' reductionist view that only the purely mechanical explanations of the physics are true, created in 1649 a new corpuscular theory, where later the great Isaac Newton would have inspired from [1, 5, 6]. Unlike Democritus' atoms, Gassendi's atoms were particles, possessing mass and inertia, that could move in the void whose existence had been experimentally demonstrated by Torricelli and Pascal. The motion was considered as an indestructible property of atoms „*purified by associations of atheistic and subversive ideas*” [5]. Gassendi has formulated the main theses of his theory with such a clarity and power of persuasion, that it has been recognized and accepted by all the naturalistic philosophers, who were in opposition to Descartes' full space doctrine.

The corpuscular theory was in an excellent conformity with the mechanistic tendencies from the naturalistic philosophy of that time. Having Galileo's tools of dynamics at hand, it was now easier to study the motion of some point particles rather than the motion of some heavenly stars. The Gassendi's corpuscular theory played an exceptional role in the further development of atomistic theory of physics and chemistry. In this regard we would mention that the definition of the atom given by Gassendi is found almost word in word in Newton's „*Optics*”, launched in 1704, that from Gassendi's and not Newton's activity would actually inspire John Dalton after 150 years to reach ultimately the founding of chemistry's atomistic theory.

The interest shown by the famous British of Irish origins physicist and chemist *Robert Boyle* (1627-1691) in his youth for the atomistic theory has led him to the formulation of two alternative hypotheses for air pressure [7]. According to the first hypothesis, the air would have been composed from mutually rejecting particles, like small springs or laminated wool yarns. His second hypothesis was based on Descartes' theory of the vortex motion of material particles and was supposing that the air consists of particles in motion mutually rejecting when colliding with each

other. Just like his predecessors, Boyle accepts the existence in nature of the absolutely empty space, where material particles of certain shape and same dimensions are found. He was considering that the atoms of the liquids are in a continuous motion, when the atoms of solid bodies are motionless, the space between particles being filled with a very fine substance. The phenomenon of adhesion of solid bodies was incorrectly attributed to the air pressure, a widespread thesis at that time. Boyle's atomism was in essence a mixture of two French doctrines. He has come to this form of atomism after reconciliation of Aristotelian physics with his famous experiences from chemistry, due to which the Boyle's atomism has been accepted by the most of English scientists.

The first hypothesis enounced by Boyle was taken over and utilized by *Isaac Newton* (1643-1727) in 1687, in „*Philosophiae naturalis principia mathematica*” („*The mathematical principles of natural philosophy*”) to prove mathematically that if an elastic fluid consists from motionless particles between whom exist rejection forces inversely proportional to the distance between them, then the density is directly proportional to the pressure [8]. But this fundamental work, that marked the further evolution of the entire physics, didn't contain the physical explanation of the relationship between the gas' (air's) elasticity and the corresponding variation of the density or volume. Shortly after explaining the laws of planetary motion by using the forces between particles under the form of points endowed with inertia, he would confess [9]: „*It seems very likely that God may had formed at the beginning the matter out of solid, massive, hard, impenetrable and mobile particles of such dimensions, forms, quantities and proportions, that make them suitable for the pursued purposes. These primitive particles, being solid, are heavier than any other porous body made up of them... No ordinary power can divide what God himself made unique in his first creation*”. Newton has made a name in the atom's physics also through his corpuscular theory, according to which the atom „*consists from envelopes inside other envelopes, more and more tight from exterior to interior*” [9]. It was a direct hint to the today's structure of the atom, made up of nucleus and electrons, which would have been forgotten for nearly three hundred years. In the 17th century the chemistry was still in an embryonic phase of development, for which reason the corpuscular analysis couldn't be applied. To reach this objective new experimental data were necessary, that would have only been acquired in the next century.

In 17th-18th centuries the atomistic theory gets a prominent mechanistic character, just like all the sciences and theories developed in that period [1, 2, 6]. The mechanistic atomicity was represented especially by Robert Boyle and Mihail Vasilievich Lomonosov, who were underpinning the explanations of natural phenomena through the idea that the constituent atoms of the substance behave like some mechanical parts in an assembly. A prominent representative of mechanistic atomism was also the Croatian encyclopedist *Roger Joseph Boscovich* (1711-1787), who elaborated the first general mathematical theory of atomism in 1758, by using the principles of Newtonian mechanics and the new mathematics of Leibniz [1, 6]. In his mechanistic philosophy the atoms were considered as simple points, that possess mass and between whom rejection and attraction forces exist, depending on the distance between them. He was the first one who has declared that the nature of the atoms forming the solids and liquids is the same as the one of the atoms from gases. Although his intention of establishing a unified theory of physical phenomena, based on the natural philosophy of Immanuel Kant, has failed, however, his ideas would be felt in the research activity of Michael Faraday, James Maxwell, William Thomson and many other scientists.

The mechanistic atomism was a general theory that, unlike ancient atomism, has offered a real image of the material world made of atoms. But how often has happened in the history of physics, because of the mechanistic character of the atomistic theory an impasse has been reached inexplaining the nature of the heat and the thermal phenomena, for unleashing their secrets being necessary the introduction of some fictive, abstract and imaginary fluids, like the „*phlogiston*” and „*caloric*”, whose existence hasn't been confirmed by experiences.

## 5. The first kinetic theories and their hystorical appreciation

The discovery of Boyle-Mariotte law in the 17th century raised new problems in the face of nature's philosophy especially the physics of gases. One of the acute problems of the physics of gases was the creation of scientific bases of gases kinetic theory, a theory that was called to explain the kinetic phenomena that accompany the motion of the molecules in gases.

In the first kinetic theories the accent has been placed on the application of the principles of mechanics to the motion of the corpuscles or material particles. Robert Boyle enunciated in 1660 a theory according to which the elasticity of the air, meaning the ability to withstand the weight of the mercury column in Torricelli's experiences, is due exclusively to its microscopic constitution [7]. He considers the air composed from a multitude of small bodies whose ability to withstand compression is what confers it elasticity. Although the Boylean elastic model has never constituted a real kinetic theory, it's important because through the presence of a large number of small bodies in gases the basic line of the modern atomic reasoning was already seen, according to which the macroscopic phenomena could be quantitatively explained based on microscopic bodies constitution.

Probably the first kinetic theory of gases was created in 1716 by the famous Swiss mathematician and mechanic *Jakob Hermann* (1678-1733) (fig. 1). In the sentence LXXXV of his treatise of dynamics „*Phoronomia, sive de viribus et motibus corporum solidorum et fluidorum libri duo*”, meaning „*Phoronomia or with regard to the forces and the movements of solid and liquid bodies*” (under „*phoronomia*” the Swiss was understanding the science, named later the rational mechanics or theoretical mechanics), he establishes, it's true without any explanations, the relation between pressure, density and the square of the average speed of gas particles [10]. But Hermann was not destined to check his own ideas, which is why the theory formulated by him wasn't appreciated by the scientific community of that time. It seems that it didn't have any influence on the further development of the physics in general and of kinetic theory in particular. With all the gaps, errors and imperfections the Hermann's kinetic theory had an indisputable quality and namely he was the first scientist who tried to quantitatively estimate the physical and mechanical properties of the gases based on natural attributes of the matter and of its particles motion.



Fig. 1. Jakob Hermann (1678-1733).



Fig. 2. Leonhard Euler (1707-1783).

The first man that formulated a real kinetic theory of gases was the great mathematician and physicist of Swiss origin *Leonhard Euler* (1707-1783) (fig. 2), in 1729 [4] or 1727 [11]. He tried to explain different properties of the air based on Descartes theory of material particles' vortex motion. Therefore he was assuming that particles forming the air are spheres made of an ether

core, around which exists a layer of real substance, meaning a layer of air surrounded in turn by a layer of water in rotation motion. While the pressure is a manifestation of centrifugal force, the Euler's humidity is determined by the ratio between the water from external layer and the real substance contained in the intermediary layer. He also assumed that all the molecules of gas are rotating with the same speed. By applying this hypothesis, he obtains the relation between speed, density, pressure and humidity, that in case of dry air is reducing to a dependency between pressure and density. Although Euler's kinetic theory has been highly appreciated by great historiographers of physics, like Clifford Truesdell, it doesn't seem that the Eulerian model of air's molecular constitution to have had any influence on the development of physics or kinetic theory of gases [4]. Probably, from this reason the theory formulated by Euler is nowadays omitted in many works dedicated to the early period of this theory's development.

## 6. The kinetic theory in Bernoulli's work

The kinetic molecular theory of gases has developed on the path indicated by the famous Swiss mathematician, physicist and mechanic *Daniel Bernoulli* (1700-1782) (fig. 3), who publishes in Strasbourg in 1738 the first scientific treatise on fluids mechanics, called „*Hydrodynamica, sive de viribus et motibus fluidorum commentarii*”, meaning „*Hydrodynamics, or comments on the forces and fluids' motion*” [11]. The theory he has developed is exposed in chapter X „*De affectionibus atque motibus fluidorum elasticorum, praeceptum autem aeris*” („*With regard to the properties and motion of the elastic fluid environments, especially of air*”).



Fig. 3. Daniel Bernoulli (1700-1782).

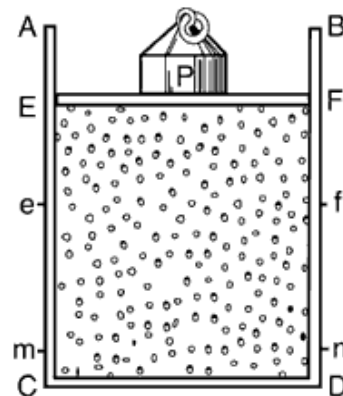


Fig. 4. The pressure of gas according to Bernoulli [12].

To study the composition and the behavior of gas Bernoulli firstly applies a reasoning based on the use of gas found in a cylinder equipped with a mobile piston (fig. 4). In the light of his theory, the gases are considered elastic fluid environments made of an infinitesimal number of small particles, that can move extremely fast in different directions and possess weight. The model proposed by Bernoulli is mostly similar to Newton's and Hermann's models. Bernoulli's biggest merit in the approached field is that he is the first who has explicitly established the kinetic origin of the pressure. Starting from the idea that the heat is the external manifestation of molecules' oscillatory motion, Bernoulli explains the pressure of the gas as a result of collision between molecules and cylinder's walls. Let's follow an excerpt from his book, where the author explains his point of view regarding the functional relationship between pressure and the volume of the gas [11]: „*The determination of weight's value  $\pi$  is required, that is capable of compressing the air contained in the volume ECDF up to the volume eCDf, in the hypothesis that the particles' speeds in those two volumes of air, natural and compressed, are equal. Let it be EC=1 and eC=S. When the cover is moving from initial position EF to final position ef, it supports an increased pressure from two*

reasons: firstly, due to the larger number of particles reported to the space where they are contained, and secondly, due to the larger number of collisions conducted by every particle". Denoting by  $S$  the ratio  $eC/EC$ , meaning the ratio of the compressed and initial volumes, with  $P$  the weight force that compresses the air and with  $m$  the distance  $mC$ , namely that „the distance to which the cover moves  $EF$  driven by an extremely large weight..., for what reason all the particles are touching", Bernoulli obtains the relation:

$$\pi = \left( \frac{1 - \sqrt[3]{m}}{S - \sqrt[3]{m}S^2} \right) P. \quad (1)$$

Because the distance  $S$  is much less than the height of the cylinder, it results  $\pi = P/S$ . Let it be now  $V_0$  the initial volume of the gas and let  $V$  be the volume, corresponding to pressure  $P$ , a reason why  $S = V_0/V$ . With these notations he obtains the equation:

$$\pi V = P V_0, \quad (2)$$

that represents the mathematical expression of Boyle-Mariotte's law. Bernoulli writes further [11]: „Therefore, between them the weight forces are basically in a reversed ratio with the volumes occupied by the compressed air in different degrees, a fact confirmed by numerous experiences. This rule can be extended as well on the rarer air than the natural one. But it could be applied also to the denser air, although this fact isn't yet elucidated. For the time being no experiments have been performed to confirm this fact. The entire problem is reduced to determination of letter  $m$ ...". Whereas the frequency of collisions of air molecules with cylinder's walls has proved to be proportional to their speed of motion  $v$ , and the produced force by each collision is proportional to the transmitted quantity of motion  $mv$ , Bernoulli shows further that the pressure is proportional to particles' the kinetic energy  $mv^2/2$ , where  $m$  is the mass of a particle. His finding was put on the fact that the increases of pressure produced by the equal increase of the temperature are proportional to the density, suggesting the idea that the temperature itself could be defined in terms of air pressure, which means that the heat or the temperature could be identified with the kinetic energy of gas' particles. To trust the truth of his saying we quote a last fragment from his book [11]: „Among other things the air's elasticity raises not just only due to the thickening, but also due to the increase of heat, because it's known that whenever the internal motion of the particles increases, the heat increases as well, resulting that the increase of the air's elasticity, without the change of its volume, leads to the increase of the intensity of particles' motion, a result that is in good agreement with our hypothesis. It's clear that to maintain the air in the position  $ECDF$  the higher a weight  $P$  is required, the higher the motion speed of air particles is. Moreover, it's not hard to prove that the weight force  $P$  must be proportional to the square of this speed, since the increase of the speed leads to the increase of both the number of collisions, as well as their intensity, so that both to be proportional to the weight  $P$ ".

Through the theory that he has developed, Bernoulli was one step away from discovering the fundamental relationship of the kinetic molecular theory of gases and the kinetic explanation of the concept of temperature. For the remarkable contributions brought to the development of the kinetic theory of gases, Daniel Bernoulli and his father, Johann Bernoulli (1667-1748), obtain the Paris Sciences Academy Award for the year 1746. But a lot of time still has to pass until this wonderful theory, initiated by Bernoulli, would gain the overall confidence of the scientists and would become part of the general physics. The influence of his ideas will be felt in the research activity of many scientists, and especially of James Maxwell.

## 7. The kinetic theory in Lomonosov's work

Newton's corpuscular hypothesis has been much improved by the great Russian encyclopedist *Mihail Vasilievich Lomonosov* (1711-1765) (fig. 5). When he initiated his first studies on the nature of heat in the years 1741 – 1743, Lomonosov relied on the ideas of corpuscular mechanics; he was already familiar with Robert Boyle's and Isaac Newton's works, as well as with Leonard Euler's and Daniel Bernoulli's realizations. Unlike his predecessors and contemporaries, he has essentially advanced in the problem of heat's nature. Generalizing and developing in a creative way the ideas of his ancestors, Lomonosov has in fact created the early kinetic molecular theory of heat.



Fig. 5. Mihail Vasilievich Lomonosov (1711-1765).

Lomonosov has dedicated several works to the corpuscular hypothesis of heat. In his most important work „*Размышление о причине теплоты и стужи*” („*Thinking about cause of warmth and cold*”), presented in 1745 at the Conference of Sciences Academy from Sankt Petersburg, he was writing that „*sufficient arguments exist of associating the heat with the matter's motion*”, made of a certain type of corpuscles that are in a continuous rotation motion [13]. He has applied the corpuscular hypothesis to the thermal phenomena of decomposition, evaporation, melting and thermal conduction. Lomonosov was explaining the process of thermal conduction in this way [13]. When a warm body is in a direct contact with a cold body, the first one cools down, while the second body warms up. This is producing because the warm body's corpuscles are rotating faster than the cold body's corpuscles. At the touch of the two bodies the motion of the rapid corpuscles is transmitted to the corpuscles of the cold body, that are rotating slower. After transmitting the rotation motion, the warm body's corpuscles will rotate slower and the body will cool down, while the rotation motion of cold body's corpuscles will become faster, having as effect his warming.

An important problem of the heat physics of that time was the problem of existence of the extreme temperature's two values – inferior and superior. Thinking on this issue, Lomonosov was writing [13]: „*It can't be defined a however great speed to not imagine an even greater. That's why the superior grade of the heat is impossible. Inversely, the same motion may slow down until the absolute resting state is attained and no further slowing of the motion can take place. Therefore, the superior grade of bodies' cold must correspond to the particles' absolute resting*”. Although this problem has been much debated in the special literature of that time, however Lomonosov was the first who has convincingly argued his ideas and has predicted the existence of the absolute zero temperature.

In the „*Опыт теории упругости воздуха*” work, meaning „*The experience of air's elasticity theory*”, Lomonosov develops an elementary kinetic theory of gases, that he applies it to the

disordered corpuscles motion [13]: „We understand ... and certainly don't hesitate that the air particles – namely those that produce the elasticity seeking to move away from one another – are deprived of any physical constitution and organized structure. They certainly can be called atoms”. Another Lomonosov's notable realization was the corpuscular explanation of Boyle's-Mariotte's law [13]: „The elasticities of the air will be inversely proportional to the volumes and proportional to the densities, that is the same”.

But Lomonosov wasn't destined to demonstrate the veracity of the enounced ideas. Probably because of this reason his kinetic theories of heat and gases weren't understood by his colleagues from the Sciences Academy and by many Western scientists, although some of them have made references to his work.

## 8. Conclusions

In the 18th century the kinetic molecular theory of gases wasn't accepted and taken seriously into account from many reasons. Firstly, in the examined period this theory was still in an embryonic development phase and the vast majority of the adopted assertions had no experimental support. Too little was known about the internal structure of the matter and its essential attribute, the motion, to create the scientific bases of the kinetic molecular theory of gases. Secondly, the physics and chemistry, that were just trying to constitute as separate sciences in the general framework of natural sciences, were dominated by the concept of caloric (phlogiston), inherited from ancient Greeks and perpetuated in 17th – 18th centuries. The success of the caloric theory in explaining the thermal phenomena and its dissemination among the European physicists have ultimately led to the stagnation of kinetic theory for a period of more than one hundred years.

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