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# Space Energy

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## 1. Introduction

### 1.1. Foreword

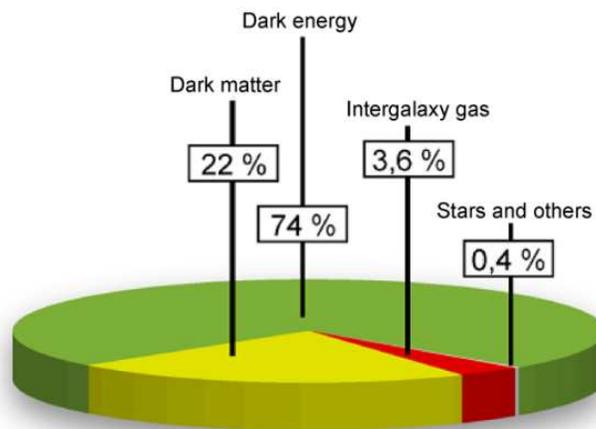
*"Our knowledge of the world is guesses and delirium"*  
Omar Khayyam

**Vacuum energy.** The present chapter considers a possible application of classical mechanics (more specifically, methods of continuum lightly moving media) for description of the enigmatic Cosmic Energy (CE). We shall not touch energy processes in the Universe conditioned by baryon substance conversions when forming and evolving stellar structures and concentrate on a specific question of modeling dominating CE vacuum that fills free cosmic space everywhere and even in case of absence of our traditional substance. Herewith our approach for CE description differs in principal from the virtual energy concept resting on virtual particles or negative pressure. We consider the CE as a real energy of movement and interaction of vacuum-filling mass particles, which in divers' time were referred to as ether particles or photons (with finite rest mass) or today particles of hidden Dark Matter (DM) [1-6].

**Dark energy.** Here we specially pay attention to widely discussed nowadays a notion of cosmic Dark Energy (DE) [6-8]. The term "dark energy" appeared in scientific literature in the end of XX Century and marked the cosmic media filling the whole Universe. DE is inseparably linked with any space cubic centimeter and according to well-known formula  $E = mc^2$  can be considered a DM equivalent. The first word in terms "dark energy" and "dark matter" means that this matter form allegedly does not emit and does not absorb electromagnetic radiation and interacts with usual matter by only gravitationally. The word "energy" opposes the given media to the structured one consisting of substance particles. DE density, unlike usual and dark, substance is similar in any space point and its pressure has negative value. The negative pressure value is the result of the thermodynamic correlation

#### 4 Energy Conservation

$\Delta E = -p\Delta V$ , which shows the increasing of energy  $\Delta E$  accompanies by the increasing of volume  $\Delta V$ . The DE state equation is written as  $p / \rho c^2 \approx -1$  [8]. The standard cosmology model gives DE up to 74% of the total mass-energy quantity of our Met galaxy. The figure shows the matter distribution in the Universe accepted today in cosmology. The modern science has carried in consideration the DE and entrusted on it responsibility for the registered accelerated Universe expansion. Thus we display in detail appropriate experimental data.



Matter distribution in the Universe

**Universe expansion.** The last hundred years it is known that Universe expands. Its possible accelerated expansion was also discussed and particularly popular this subject became since 1998 when the works [9] were published. Observations of distant Super Nova show that galaxies scatter from each other with all greater and greater speed. Today this result is considered without doubts. It was noted as a grandiose achievement of modern physics and awarded a Nobel Prize for 2011 [10].

We think necessary to emphasize that the conclusion about accelerated Universe expansion entirely rests on a postulate about constant light speed in vacuum  $c = 2,998 \cdot 10^8$  m/s and about impossibility to exceed the given speed value by moving bodies. Meanwhile we have to acknowledge that modern science does not dispose reliable data on measured light speed in the early hot Universe. If in hot Universe the light speed in vacuum exceeded its known today value, than the observed accelerated Universe expansion would get a natural trivial explanation. We again return to its usual (not accelerated) expansion and no necessity to carry in consideration the hypothesis of DE presence in Universe. Therefore the given fact of allegedly accelerated should be interpreted as validation of possible light speed dependency on temperature of cosmic vacuum. Note in this connection some published experimental data on measured superluminal light propagation.

**Superluminal speed.** The history of experimental registration of superluminal light propagation is as old as its prohibition. This phenomenon was thoroughly studied already in 30-s of last Century. Thus in [11-15], in particular, it was stated that in hollow metallic

tubes electromagnetic waves can have superluminal propagation. The effects of superluminal propagation of laser electromagnetic pulses were open and studied in 60-s in academician N.G. Basov's laboratory [16,17]. Measured isolated pulses propagation was 6-9-fold light speed in vacuum. In experiment [18] recorded pulse propagation in inverse populated cesium vapor was 310-fold light speed in vacuum. During last 20 years such type experiments [19-21] as well as experiments on superluminal tunneling [22-25] also registered a notable excess of vacuum light speed. Superluminal propagation of centimeter radio waves recorded in [26] and discussed in [27, 28].

Review [29] attempts to explain the specified effects from the standard physical theory. However some published experimental results are rather difficult to interpret in such a way. Some last empirical data on superluminal effects in hot hollow metal tube are presented in [30-33]. The mentioned experimental facts of superluminal propagation of electromagnetic waves and isolated pulses have a principle meaning under building adequate natural physical theories.

**Causality.** One of the fundamental tenets of modern physics is the sacred causality principle stating that no signal can be transmitted faster than light  $c$ . It is confirmed that at speeds higher than  $c$  events sequence becomes inverse, the events band allegedly rolls back. However this widely spread misunderstanding itself rest on a postulate that light speed is a maximum possible velocity of interactions propagation. Invalidity of such a statement about violation of the Principle of Causality can be easily shown by the following example. We consider another similar postulate ("sonic postulate") stating that sound speed in a free atmosphere space is a maximum possible velocity of interactions propagation. Then supersonic propagation will naturally violate sonic principle of causality. An unambiguous conclusion: superluminal propagation like supersonic one does not violate the principle of causality.

**God particles.** Rather full analysis of the question about Cosmic Energy is impossible without regarding links with a fundamental question about the God Particle existence – Higgs boson [34] responsible (as someone thinks) for birth of baryon matter mass. Due to careful last year's experiments at the Tevatrone and Large Hadron Collider this question now is close to its objective decision. "To be or not to be" of the Higgs boson – leading world physics forums solve today [35-37]. Still we have no positive answer for this question, and a possible creation of theoretic physics models are under consideration beyond standard model limits [38] (e.g. models of extra dimension, super symmetry, top quark physics, etc.). However alongside with the mentioned up-and-coming directions one should not forget about classic physics models up to limits of ditto time standardized models. Here the typical example may be the Hidden Mass Boson (HMB) [39, 40], which also as the Higgs boson might take itself the responsibility for the baryon matter birth.

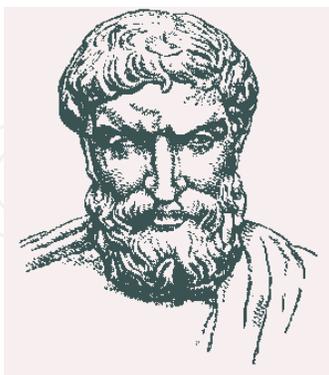
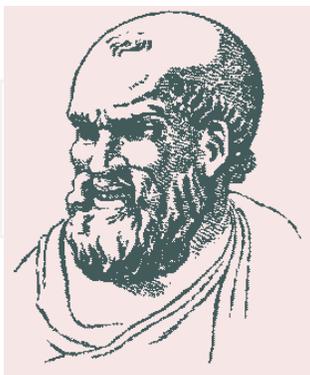
The chapter materials offered to the Reader is entirely based on the traditional classic physics. We show the Cosmic Space contains gaseous medium of HMBs with temperature  $T=2.725$  K and study in detail this medium. *The Space Energy presents in our case the kinetic*

*energy of HMB particles.* We demonstrate the Grand Unified Theory of electromagnetics, weak and strong interactions, electrovalence linkages and antimatter. As additional experimental confirmations we use the Hooke law, the Dulong–Petit law, the thermal expansion law and oth.

## 1.2. From ancient history

*“Namely from Leucippus’ schooling the era of atomistic in science has started, which is a theoretical foundation of physics and is continuously developing up to present days. Therefore we can with full right consider Leucippus as the “Father” of theoretical physics”*  
V. Fistul

Theoretic premises of the present chapter are very close to the old Greek philosopher Leucippus (V century B.C.). In his main work “Great space order” (“Μεγάζ διακομοζ”) Leucippus has developed the atomic matter theory for near Earth and Space. His more known student Democritus continued to deeply advance the theory and summarized it on the “Micro space order” (“Μικροζ διακομοζ”). These two original works of materialism allows to speak of the “Leucippus – Democritus line” in the human through development. About a century and a half later old Greek philosopher Epicurus seemed to complete the development of ancient direction of atomic matter theory and publishes a final work “On atoms and vacuum”. Their successor poet-philosopher of antic Rome Titus Lucretius Carus (first half in I century B.C.) brilliantly described this theory in his famous poem “On the Nature of Things” (“De Rerum Natura”). Note specially, the developed theory of antic atomism was the most successful theory, actually spread the atomism up to the matter “subbaryonic” level and presented it as an “information bearer” for a human being.



Democritus circa 470 – 390 B.C. Epicurus circa 341 – 271 B.C. Lucretius Carus circa 95 – 55 B.C.

In conclusion we cite a brightest inference of ancient materialism by Lucretius Carus [41]:

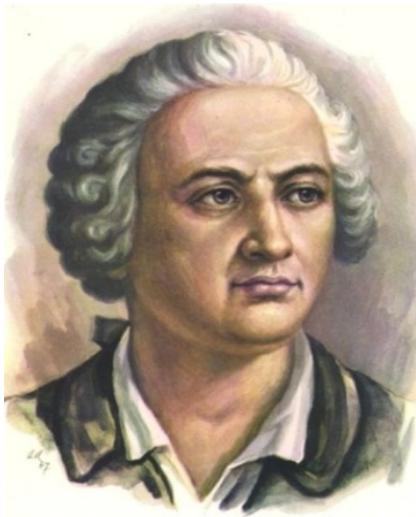
*“In is clear from here that the essence of soul and intellect  
Has been created undoubtedly from primary particles petty,  
And absence of their gravity does not lessen their essence”.*

### 1.3. From XVIII-XIX centuries

*“The ether finest substance filling the whole invisible world is capable to possess this movement and heat and also it transfers this movement obtained from the Sun to our Earth and other planets and heat them, so the ether is a medium by means of which the bodies separated from one another transfer heat to each other”.*  
M.V. Lomonosov [42]

The question of space energy and heat nature was thoroughly studied by Russian scientist M.V. Lomonosov in the middle of XVIII Century. In his original work “About the reason of heat and cold” [42] he argues that “the heat consists of substance movement and this movement though not always sensitive but really exists in warm bodies. This movement is internal, i.e. insensitive particles are moving in warm and hot bodies, and bodies themselves comprise these particles.” Considering the heat (energy) nature in the form of finest substance particles and ether movement, Lomonosov in ditto time sharply raises an objection to another interpretation of heat nature in the form of hypothetical heat generation (phlogiston), when the body heat is tied with heat generation quantity and heat transportation is connected with heat generation flow from hot bodies to the cold ones. Lomonosov says: “We confirm that the heat cannot be prefixed to concentration of some fine substance no matter its name...”. The present chapter demonstrates from modern scientific positions the fairness of many Lomonosov’s conclusions regarding the heat (energy) nature.

We want to underline that the heat generation concept (phlogiston concept) in spite of justified critiques has continued to dominate in science for about 100 years. Thus Saudi Carnot leaning on the heat generation model in his wonderful work “Cogitation about fire propulsive force and about machines capable to develop this force” published in Paris, 1824 comes to few basic results of heat theory and formulates a principal idea of heat and work equivalence. He writes in his later researches: “The heat is not that other but propulsive force or rather movement that changed its shape; it is body particles movement; everywhere propulsive force disappears at once the heat generates in qualities exactly proportional to the disappeared propulsive force quantity. Otherwise, always when heat disappears the propulsive force originates.” To present the “propulsive force” notion later the scientists started to use the term “energy”. We give also Carnot’s formulation of the energy conservation law: “Thus one can say a common expression: the propulsive force exists in the nature in constant quantity; generally speaking, it is never produced, is never destroyed; actually it can change its shape, i.e. it generates either one movement type or another, but never disappears”. We find further development of the energy conservation thermodynamic law in works by Mayer, Joule, and Helmholtz the latter gives its generally accepted mathematical formula.



M. V. Lomonosov (1711-1765)



Sadi Carnot (1796-1832)



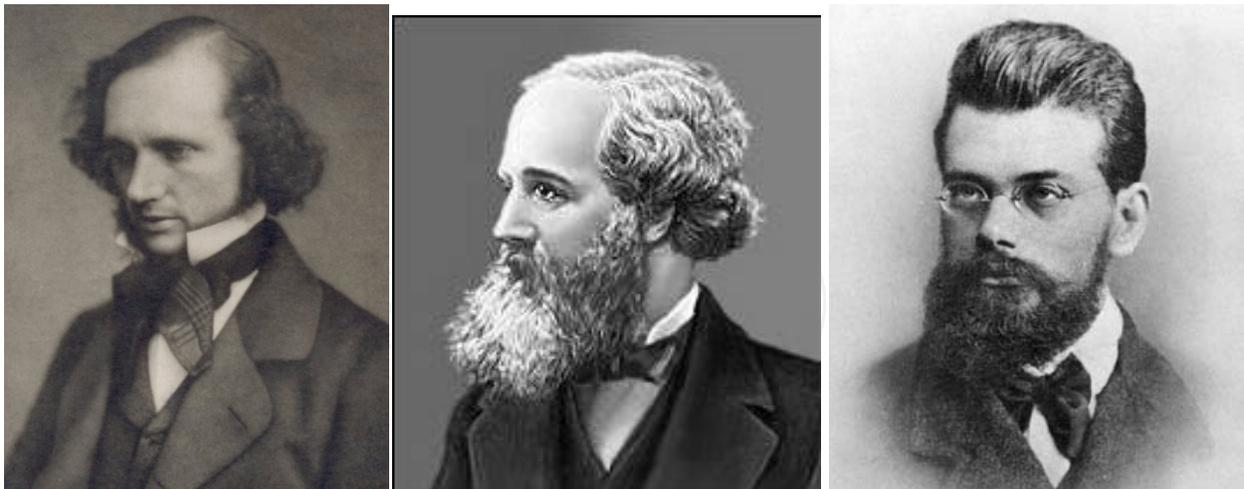
Rudolf Clausius (1822-1888)

Beginning with R. Clausius and W. Thomson studies in 50-s of XIX Century the heat nature is finally connected with certain particles movement type. The basic Clausius work "Mechanical heat theory" considers "light heat as ether fluctuating movement"; in bodies "the heat is movement of substance and ether fine particles", and "heat quantity is a criterion of this movement live force". R. Clausius developed the basics of classic thermodynamics and proposed a convenient form of their presentation as the first and second beginnings.

W. Thomson in his studies on heat theory and, in particular, in work "About heat dynamic theory" also believes that "heat is not a substance but a dynamic form of mechanical effect" and "certain equivalence should exist between work and heat". In contrast with R. Clausius, W. Thomson especially pinpoints an idea that the second thermodynamic beginning expresses the energy dissipation process. Thus, W. Thomson believes, the nature is under control of the "energy dissipation principle". The idea of "the Universe heat death" is known follow from this principle.

The second half of XIX Century is marked by outstanding James Clerk Maxwell and Ludwig Boltzmann works on the theory of thermogasdynamical processes. In review monograph "Substance and movement" Maxwell gives the following definitions: "The energy is an ability to conduct work", "The heat is an energy type" and explains that "warm body fine particles are in a state of quick chaos agitation, i.e. any particle always moves very quickly and its movement direction changes so fasten that it displaces very small or does not displace at all from one place to another. This is true, a part, and may be very big part of warm body energy should be as a kinetic energy type".

In addition to the mentioned citing it is very important for further discussion the Maxwell's weighted velocity wise distribution of similar particles system uniquely determined by system temperature and particles mass. Presently the formula has a title: the Maxwell-Boltzmann equilibrium velocity distribution formula. Our work main conclusions in much degree are based on this distribution.



William Thomson (1824-1906)    James Clark Maxwell (1831-1879)    Ludwig Boltzmann (1844-1906)

Principal questions of thermodynamic theory from standpoint of gas kinetic theory are studied by Ludwig Boltzmann. His "Lectures on gas theory" [43] begin with words "Already Clausius strongly distinguished the general mechanical heat theory based mainly on the two theorems, by his example called the elements of heat theory, from the special theory, which, firstly, certainly believes that heat is a molecular movement and, secondly, attempts to develop a more accurate interpretation for this movement character." Using statistic approach Boltzmann analyzes main positions of the mechanical heat theory.

Completing the review of energy theory origins we additionally underline that foundations of electromagnetism theory are obtained by Maxwell also on the base of ether concept [44]. It is well known, Maxwell in his basic "Treaties on electricity and magnetism" used a model of light ether as an invisible fluid. In particular, in the article "About Faraday power lines" he writes: "Reducing everything to purely mechanical idea of some imaginable fluid movement I hope to achieve generalization and accuracy and avoid the dangers that occur at attempts with the help of premature theory to explain phenomena reasons."

Discussion on questions of physics basics, and first all, "what actually exists - matter or energy", unrolled sharply on the edge of XIX and XX centuries. In a bright report "On development of theoretic physics technique in the newest time" delivered at a Nature Scientists Meeting in Munich, September 22nd, 1899 Ludwig Boltzmann considers this question from the positions of classic atomistic mechanics. Touching electromagnetic phenomena he, in particular, says: "The matter is that alongside with weighted atoms the existence of special substance made of significantly smaller atoms, namely, light ether been allowed. In turned out possible to explain nearly all right phenomena, which earlier Newton referred to do a specific light particles emanation, by lateral ether oscillations. Though some difficulties remained, for instance, it was unclear why there is complete absence of longitudinal waves in the light ether, which in all weight bodies both exist and play major role". Further in that report, expressing care about the approaches of newest "energetic" physics being published Boltzmann exclaims: "I have remained the last among those who admitted the old by all their soul; else I am the last who still struggles for this old whenever

possible. I see my vital task as the following: by means of possibly clear and logically regulated development of the old classic theory results to make if in future not-necessary to re-discover a lot of good and still suitable things, that, in my opinion, are contained in this theory, as it repeatedly happened in this history of science". Let's cite as well another Boltzmann's idea said in the end of that report: "Whether once again would the mechanistic philosophy with the battle, having at last found a simple mechanic model of light ether, at least would the mechanic models maintain their meanings in future or would a new non-mechanic model be accepted the best?"

#### 1.4. From XX century

*Sir, I tell you on the level:  
We have strayed, we've lost the trail.  
What can WE do...*

*A.S. Pushkin (1830)*

The mechanical philosophy has suffered a major defeat from creation of special and general theories of relativity. The authors of basics of the special theory of relativity (STR) rested entirely on the two widely discussed scientific results of that time. The first followed from unsuccessful experiments on detection of light-bearing ether (famous experiments by Michelson – Morley). A. Poincare, one of the STR authors writes about it in 1895: "Experience has given a lot of facts, which admit the following generalization: it is impossible to detect absolute matter motion or, more exactly, relative motion of material matter and ether. All that is possible to do – to detect material matter motion relative to material matter". The principal generalization cited becomes further the first STR postulate. Below this postulate is given from P. Tolman monograph [45] approved by A. Einstein himself: "It is impossible to detect the uniform progressive motion of a system in free space or in any hypothetical ether media, which could fill this space". Therefore it is reasonable to speak only about relative movement of two systems and no sense to mention absolute motion (for example, absolute system motion relative to the universe ether). From this viewpoint, there is no necessity in the mechanic ether.

The second scientific result deals with the field of theoretical research of that revolutionary time. For the first time these linear transformations of space-time coordinates named after Lorentz were obtained in 1887 by V. Fogth as transformations preserving the invariance of d'Alembert wave equation. In 1900 G. Larmour showed that the Maxwell's electrodynamics equations in free space are also invariant regarding these transformations. Later in 1904 they also were written by Lorentz and since 1906 by Poincare proposal were named the Lorentz transformations. Considering peculiarities of the Lorentz transformations Einstein points out: "Velocities of material bodies exceeding speed of light are impossible, that follows from appearance of the radical  $\sqrt{1-v^2}$  in formulas of the particular Lorentz transformation". Assuming, that at transition to a system moving with  $v$  speed the time-space coordinates changes in accordance with the Lorentz transformations, quite naturally the second STR

postulate becomes effective: “the speed of light in free space is identical for all observers regardless relative velocities of a light source and observer”. The speed of light  $c$  in free space may now be considered as the maximum allowable speed and, first of all, the maximum speed of interactions propagation. “Unification of the relativity principle and limit speed of interaction propagation is called the principle of relativity by Einstein (it was formulated by Einstein in 1905) is contrast with the principle of relativity by Galileo, which is based upon the infinite velocity of interaction propagation,”- read the “Field theory” course L.D. Landau and E.M. Lifshitz [46].

Thus the STR erects an insurmountable “light barrier” for allowable matter motion speeds and for any weak or strong signals propagation speeds (speeds of information propagation). It completely rejects the body ether of XIX century. The Einstein’s article “About the ether” begins with the words: “Speaking here about the ether we surely do not mention the physical ether of mechanic wave theory which obeys the Newton laws and some points of which have velocity. This theoretic presentation, in my opinion, has completely gone off the scene with the creation of the STR”. Roughly so reads a verdict to the classic physical ether.

The ideas of STR are developed in the General Theory of Relativity (GTR) created by Einstein in 1906 – 1915. The physical processes in GTR are described in a curved space-time system with variable metrics. The curvature of space-time allows to build an interesting model of gravitational interaction based on similarity between the results obtained in gravitational field using a uniformly moving reference system and results in absence of a gravitational field with an accelerating reference system. This similarity is accepted as the second GTR postulate and called the equivalence principle. The GTR realizes in full the idea of relativity of any motion.

Further physics development in the XX century was dominated unconditionally by the GTR and STR and, naturally, was brightly imposed on the whole modern theoretical physics.

## 2. Key experimental data

*“A Rational Being! Turn your eyes to the serene sky.  
What a wonderful order is there!”  
Kozma Prutkov (Russian man of sense, literary person).*

### 2.1. Cosmic microwave background radiation

One of the important achievements of experimental astrophysics of the second half of the XX century was the discovery of the Cosmic Microwave Background (CMB) radiation. The existence of this radiation was predicted by George Gamow in 1948. According to his idea of the Universe origin as a result of the Big Bang, the current radiation appeared at the initial stages of the Universe development and it was “severed” from the matter spreading this radiation and so far it has cooled off to a very low temperature. The temperature of CMB was predicted by Gamow also (accurate within 7 K). In 1955 the post gradient radio

astronomer T.A. Shmaonov in the Pulkovo Observatory experimentally observed noise microwave radiation with the absolute value of the effective temperature  $4\pm 3$  K. After Shmaonov had defended his dissertation, he also published the article [47].

In 1966 CMB was registered by the American astronomers A. Penzias and R. Wilson [48]. The careful researches of the last decades showed that the distribution of the radiated density does not depend on the direction of its registrations, and that it corresponds to the equilibrium radiation of a black body with the  $T=2.725$  K. These properties of radiation discuss the possibility that we don't have the case with transformed radiation of stellar objects but with the independent substation filling the entire Universe. According to Ja.B. Zeldovich [49] CMB was sometimes called "new ether". This name was given as a result of dipole anisotropy discovery of CMB at the middle of 70-years [50]. This circumstance allows the introduction of the absolute cosmological frame of reference in the vicinity of our own Galaxy where the background radiation is isotropic (accurate within small-scale fluctuations).

Before the discovery of CMB with the final value of the temperature  $T$  it was thought that the temperature in the vacuum of cosmic space is  $T=0$  K and the pressure of the vacuum is  $p=0$ . These values conformed to the properties of carries of electromagnetic radiations – photons with their rest mass  $m=0$ , the velocity of their moving in a free space can be equal to the speed of light in vacuum  $c=2.998\cdot 10^8$  m/s only, their impulse  $P$  and energy  $E$  that connect with each other by the formula  $E=Pc$ . The photons do not cooperate with each other, and their totality behaves as ideal gas (with the adiabatic index  $\kappa=4/3$ ).

However, the discovery of the final temperature of CMB  $T=2.725$  K should cardinaly change the situation. By virtue of the kinetic theory by L. Boltzmann [41] and the dimensional analysis [51-53] (the  $\pi$  - theorem by E. Buckingham [54]) we come to the final values of pressure and the mass particle in the physics space vacuum

$$p = nkT, m \sim \frac{kT}{c^2},$$

where  $k$  – the Boltzmann's constant,  $n$  – concentration of particles in examining space. Thereby we introduce with necessarily the ideal gas mass medium to the cosmic space (physical vacuum). This medium can be identified with the mass photon gas or the Dark Matter (DM) of the 20th century or it can also be considered as the classic ether of the 19th century. In the present work for such a medium the particle structure is based and called Hidden Mass Boson (HMB).

## 2.2. Dark matter

We shall present the main experimental facts proving existence of Dark Matter (DM), which were repeatedly described in literature, (see [1-7]).

Astronomer Oort set the problem of possible presence of DM in the Universe in 1932 with connection to his measurements of motion of stars in the disk of our Galaxy Milky Way. An unexpected conclusion of his measurements was an essential lack of the aggregate Galaxy weight for explanation of rotational speeds of the disk. One year later astronomer Zwicky,

studying dynamics of the clusters of galaxies, has come to the conclusion, that the observed weight makes only about 10% of the total mass required for a reasonable explanation of observations of the total mass in the clusters of galaxies. Special spectroscopic and radiosopic observations of rotational speed of hundreds of spiral galaxies were executed later. These observations have shown the essential increase of total mass of galaxies in the direction of the edge of the stars disk. These facts indicated to presence of the spherical material halos surrounding the spiral galaxies, which could not be registered in the other way (i.e. was invisible). Careful observations of elliptic galaxies and clusters of galaxies have also indicated to the presence of the invisible dark matter gravitationally interacting with the visible objects of the Universe.

The other experimental confirmation is the hot gaseous congestions. Explanation of their existence with registered parameters requires presence of DM in quantities noticeably exceeding the visible matter. We underline, that the empirical fact of the DM existence in Meta-Galaxy is now conventional.

DM at present time is one of the most intriguing mysteries of the nature. There were multiple attempts to describe the nature of DM, but no one was successful yet (see [4, 5]). As it was already noticed, DM (with DE) makes not less than 96% of all matter of our Meta-Galaxy. A number of theoretical models of DM based on principles of the modern physics are proposed. Spreading of mass value of the DM particles in different theories reaches 78 to 80 orders: from mass values of  $10^{-6}$  eV for ultra-light (sterile) axions up to values of about  $10^6 M_0$  ( $M_0$  is the mass of Sun) for supermassive black holes (in kilograms this range corresponds to mass values from  $10^{-42}$  to  $10^{36}$  Kg).

We shall briefly list the main candidates for the DM particles. The main candidates for the baryonic DM are the Massive Astronomical Compact Halo Objects – MACHO. Usually MACHO includes dwarf stars (white, black or brown dwarfs), planet such as Jupiter, neutron stars and black holes. The careful analysis of the aggregate contribution of the listed baryonic objects to the total substance mass of the Universe performed last years has shown that the DM problem cannot be solved with help of the baryonic matter only. We repeat that the aggregate estimation of the all baryonic matter in the Universe makes less than 5% of the total matter.

Non-baryonic DM is usually divided into two main categories: Cold Dark Matter – CDM, which particles moves at subluminal velocities, and Hot Dark Matter – HDM, which particles should move at relativistic velocities, close to that of light in vacuum. The main candidates for CDM should be Weakly Interacting Massive Particles – WIMP with mass of 1 GeV and more. Now intensive searches of such particles with the help of different special detectors are under way [5-7].

The ultra-light sterile axions with mass in range of  $10^{-6} \div 10^{-3}$  eV are considered as hypothetical DM particles. Axions were introduced into the theory of elementary particles in order to explain violation of the CP-invariance in the early Universe [55, 56]. Axions should

breakdown into two identical photons under action of an external electromagnetic field [56]. With the purpose of registration of such disintegration and confirmation of the axions existence, the super-sensitive axion detectors are developed now.

Neutrino and anti-neutrino are the characteristic particles of HDM. Their mass, as candidates for HDM, should be in the range of 10 to 100 eV.

Other candidates for DM are different super-symmetrical particles, which could be formed at the initial moments of the Universe existence (when it was “super-symmetrical” and when all the four interactions were united). Detailed information on all possible hypothetical DM particles is presented also in the proceedings of the last conferences on particle physics [35-38].

### 2.3. Some astrophysics data

**Gamma-ray bursts.** An actual unsolved problem of astrophysics is the problem of powerful bursts of gamma radiation, which registration began in the middle of 60's with the help of special equipment of reconnaissance satellites [57, 58]. Now similar bursts are registered 3 to 5 times a day and are intensively studied [59-62]. An important feature of the gamma-bursts is their after-glowing in x-ray and light ranges, which approaches Earth considerably later than initial bursts do.

The delay time of after-glowing can be more than one year [60, 61]. At the present time there is no theoretical model, adequate to the phenomena of the gamma-bursts propagation to the large cosmological distances, which could explain absence of apparently essential energy losses of the propagating bursts.

**Cosmic rays.** Origin of the cosmic rays of ultra-high energy (more than  $10^{20}$  eV) is a difficult to explain problem of astrophysics [63-65]. The registered energy level greatly exceeds the permissible by theory limit of the energy spectrum of particles of the primary cosmic rays (because of the known effect of interaction with relict photons of Greisen-Zatsepin-Kuzmin (GZK) [66]). Unanswered questions are both the mechanism of the charged particles acceleration to the high energy levels and capability of their propagation to the huge cosmological distances without essential energy losses. The explained problem is called “GZK paradox”. Theoretical approaches beyond the framework of the modern standard models of theoretical physics are proposed (see, for example [35]).

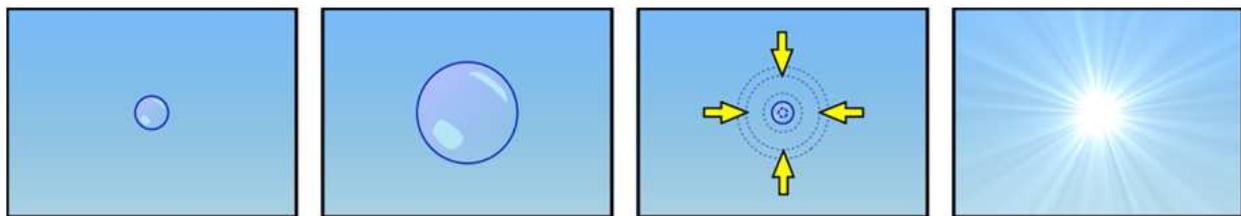
**Cosmic jets.** The extragalactic “superluminal” jets propagating from the centers of quasars and active galaxies remain an astrophysical enigma [67]. Registered during the last years velocities of propagation of such jets exceed the speed of light in vacuum by 6 to 10 times [68-70]. One of the latest publications on this subject informs of the presence of a giant jet of more than 300 kilo parsec of length (one million light years) at quasar RKS 1127-145 containing more than 300 “barrels” [71].

In the last time during two decades, there is considered also the mentioned earlier accelerating expansion of the Universe. The accelerating expansion means that the Universe

could expand forever until, in the distant future, it is cold and dark. The team's discovery led to speculation that there is a "dark energy" that is pushing the Universe apart [9, 10]. Astronomers and physicists have so far failed to discover the nature of this strange, repulsive force with negative pressure [8].

## 2.4. Electromagnetic evidences

**Sonoluminescence.** Sonoluminescence is the emission of short bursts of light from imploding bubbles in a liquid when excited by sound [72, 73]. Sonoluminescence can occur when a sound wave of sufficient intensity induces a gaseous cavity within a liquid to collapse quickly. This cavity may take the form of a pre-existing bubble, or may be generated through a process known as cavitation. Single bubble sonoluminescence occurs when an acoustically trapped and periodically driven gas bubble collapses so strongly that the energy focusing at collapse leads to light emission (Figure 1). Detailed experiments have demonstrated the unique properties of this system: the spectrum of the emitted light tends to peak in the ultraviolet and depends strongly on the type of gas dissolved in the liquid; small amounts of trace noble gases or other impurities can dramatically change the amount of light emission, which is also affected by small changes in other operating parameters (mainly forcing pressure, dissolved gas concentration, and liquid temperature). The light flashes from the bubbles are extremely short—between 35 and a few hundred picoseconds long—with peak intensities of the order of 1–10 mW. The bubbles are very small when they emit the light. Transfer of shock wave kinetic energy to light burst energy may be simulated with help of the conservation law system from the section 4.4 of the chapter.



**Figure 1.** Sonoluminescence main stages

**Displacement current.** The proposed in this chapter physical model of vacuum and the suggested structure of the HMB give very clear interpretation of the Maxwell displacement current and the Umov-Poynting vector. Firstly, we are reminded of the spread example of necessity to introduce the displacement current to Ampere's law. For instance, a parallel plate capacitor with circular plates is charged by current  $I$  (Figure 2). The magnetic field in the point at a distance  $r$  from the conductor can be calculated by Ampere' law

$$\oint \bar{B} d\bar{s} = 4\pi \frac{k_0}{c^2} \int \bar{j} d\bar{A}.$$

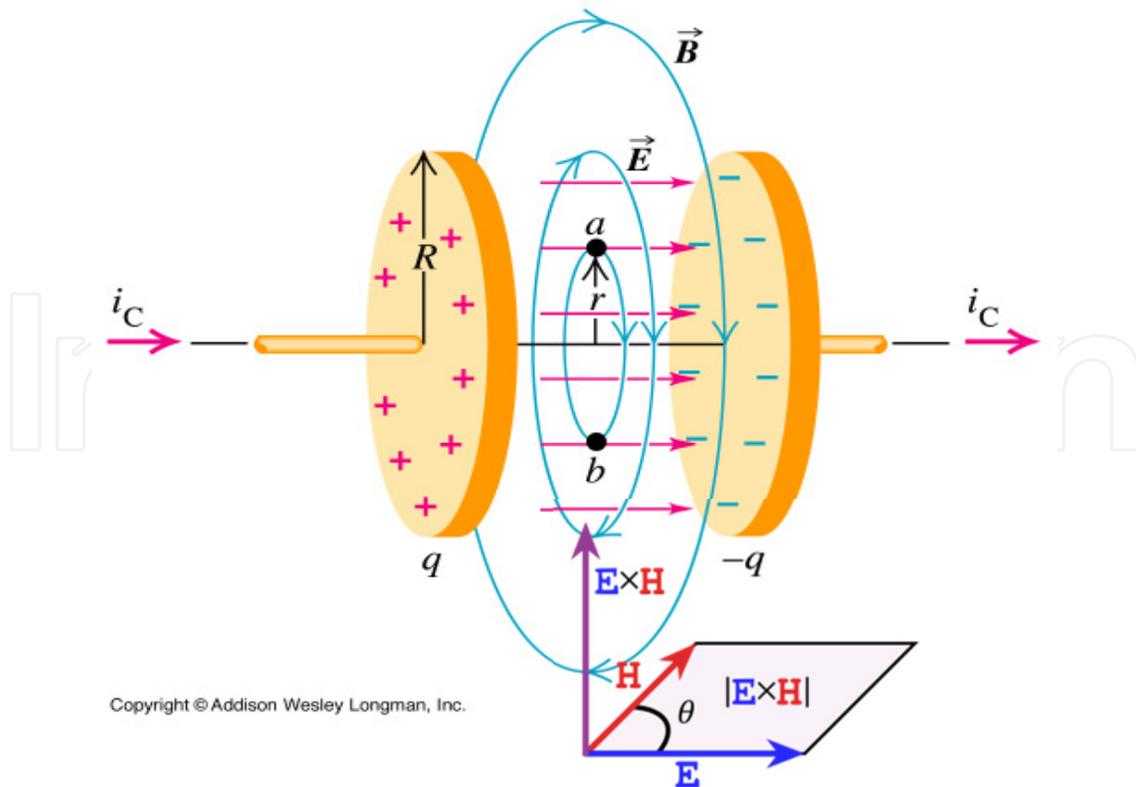
Integrating with respect to the circle we will obtain the magnetic field in the point  $P$

$$\bar{B} = \frac{2kI}{c^2 r},$$

where  $I = \int_S j dA$  is summed current flowing through the surface  $S$ . The Ampere's law has to issue for surface  $S'$ , that is based on the same circle but coming between plates of the capacitor. By adopting this method the availability of current and electric field between the plates of the capacitor, the displacement current is introduced to Ampere's law has an additional term

$$\oint \bar{B} d\bar{s} = 4\pi \frac{k_0}{c^2} \int j d\bar{A} + \frac{1}{c^2} \int \frac{\partial \bar{E}}{\partial t} d\bar{A}$$

The last term was introduced by Maxwell (and was named the displacement current). The physical meaning of the displacement current in our case is the displacement of dipoles of HMB and their re-orientation between the plates of the capacitor. In vacuum (when dielectric is absent) availability of the displacement current between the plates of the capacitor comes to the polarization of real HMB dipoles and we see clean and real physical interpretation of this current.



**Figure 2.** The Maxwell displacement current and the Umov-Poynting vector.

**The Umov-Poynting vector.** Now we examine the Umov-Poynting vector of the electromagnetic energy flux. With changing of electric field  $E$  within capacitor, its internal volume acquires energy. The energy flux is described by the Umov-Poynting vector  $\vec{E} \times \vec{B}$  and has direction from the edges of the plates to inside of the capacitor (Figure 2) from its surrounding space. As well as the displacement current in our case (availability of the HMB dipoles) the energy flux of electric field has physical meaning and connects with the moving (flowing) of dipoles from surrounding to inside.

The propagation of current inside the conductor takes place when the incidence of electric potential along the conductor and the availability drops electric field  $\vec{E}$  inside and close to the conductor which in turn is directed alongside the conductor. Availability of the current induced magnetic field  $\vec{B}$  around the conductor is directed on tangent to the circle around the wire. The vectors  $\vec{E}$  and  $\vec{B}$  are perpendicular. There is energy that flows to the inside of the conductor from all sides and which accompanies an energy lost by the conductor as heat.

The classic theory shows that electrons take their energy from outside, which means from the energy flux of the outside field to the inside of the conductor. Existed HMBs in electric dipole form are created by the energy flux going to the conductor, which in turn is processing electric current along it more clearly. The same natural interpretations we get to known phenomena of inductance and self-inductance.

### 3. Key theoretical items

*“And for the rest, summon to judgments true,  
Unburied ears and singleness of mind  
Withdrawn from cares; lest these my gifts, arranged  
For thee with eager service, thou disdain  
Before thou comprehendest: since for thee  
I prove the supreme law of Gods and sky,  
And the primordial germs of things unfold,  
Whence Nature all creates, and multiplies  
And fosters all, and whither she resolves  
Each in the end when each is overthrown.”  
Titus Lucretius Carus [41]*

Theoretical models of the nonlinear dispersion processes considered below are wholly based on the experimental facts and principles of the Newtonian mechanics. When describing these processes, the independent variables are time  $t$  and three spatial coordinates  $x, y, z$ , i.e. motion of a material medium is supposed in the three-dimensional Euclidean space. Taking into account fundamentality of concept of time and space and broad discussions of this problem held in the XX century, we shall briefly consider this and other problems which are important from the point of view of the present chapter (in particular, concepts of the subbaryonic dark matter and dark energy, principle of relativity and some other principles).

### 3.1. Time

*“Absolute, true, mathematical time itself and its essence,  
without any relation to anything external flows  
uniformly and in another way called duration”*

*I. Newton “The Beginnings” [74]*

*“The time does not exist by itself, but within the subjects,  
We all feel it, when something happened in the past,  
Whether it happens now, or in the future it will follow...”*

*So far, one has never considered the time*

*Without its relation to the bodies’ motion or their sweet rest.”*

*Lucretius Carus “De Rerum Natura”[41]*

**Absoluteness and one-dimensionality.** In the Newtonian mechanics, the basic property of time is its absoluteness. This property means that time does not depend on the selected reference system. Any time interval  $\Delta t$  is the absolute invariant for any nature process and does not depend on course of the considered processes. It is convenient in many cases to accept a second as a reference time unit and to define it as a basic unit for the time measurement.

Time is one-dimensional and common always and everywhere.

**Homogeneity.** Another important property of time is its homogeneity. Homogeneity of time characterizes its uniform development and supposes equivalence of all moments of time. This property allows to arbitrary select the zero time reference, i.e. an instant  $t=0$ , and reference interval of the time measurement. It is convenient to study the development of any process from its initial reference point and to characterize it by the current moment  $t$ , measured by the selected interval (measurement unit). It is also convenient to connect the absolute time with our Universe and assign the initial reference point to the moment of the Big Bang.

**Single directivity.** Property of single directivity of time consists in its development in one direction only – forward, i.e. increasing its value. It cannot be turned back to the past. In other words, there is a so-called arrow of time [75] (from the past to the future). Thus the principle of causality is fulfilled – corollary depends on the reasons, causing that, i.e. the present order of things depends on the past only and does not depend on the future. We underline, that in our case the causality principle is fulfilled unconditionally and irrelevant to any reference value, for example, to the speed of light in vacuum (velocity of propagation of a signal or disturbances). Within the framework of the Newtonian mechanics, the speed of light in vacuum is not the maximal possible velocity of the information transfer.

**Abstractness and infinity.** Property of abstractness of time is perfectly formulated by Lucretius Carus in the epigraph quoted at the beginning of this paragraph. The property of infinity speaks about absence of the beginning and end of the time flow.

So, we shall use the absolute, one-dimensional, homogeneous, unidirectional, infinite, abstract definition of time. Such concept of time lies in the foundation of the Newtonian

mechanics. It was widely used at the dawn of the scientific development in the natural philosophy (Leucippus, Democritus, Epicurus, Lucretius Carus). Transition from the “mathematical” abstract time to the “physical” one is related to selection of the reference point of counting and interval of time measurement.

### 3.2. Space

*“Absolute space by its essence,  
Regardless to anything external,  
Remains always identical and fixed...”*

I. Newton “The Beginnings” [74]

*“There is no end of any side of the Universe,  
For otherwise it surely would have the edges;  
Nothing can have the edges, obviously, anything, if only  
Outside of it there is nothing, that it separates,  
That would be visible*

*Our feeling was, up to monitor it is capable...  
Also is indifferent, in what you are parts installed...”*  
Lucretius Carus “De Rerum Natura”[41]

**Absoluteness, three-dimensionality, isotropy and homogeneity.** Rather customary for our usual life the absolute three-dimensional Euclidean space forms the basis of the Newtonian classical mechanics. It is isotropic and homogeneous. All points of the space and all directions are equivalent. These properties of space allow to arbitrary select a point of origin of three independent Euclidean coordinates  $x, y, z$ , (for example, rectangular Cartesian) and direction of the coordinate axes. It is convenient to combine the coordinate origin of the absolute space with an initial point in space, where in limit Big Bang was concentrated. Thus, the problem of selection of direction for the coordinate axes of isotropic absolute space will not be essential. All other coordinate systems should be considered relative to the selected unified absolute system.

**Abstractness and infinity.** Space is abstract and infinite. Similarly to time it “does not exist by itself, but in subjects we feel it”. Space is infinite in all directions. Similar to the time variable, the transition from the “mathematical” abstract space to the “physical” one consists in selection of a system of spatial coordinates and unit of length measurement.

**Invariant interval.** The main geometrical invariant when transiting from the absolute system of Cartesian coordinates to another Cartesian system will be value

$$\Delta s^2 = \Delta x^2 + \Delta y^2 + \Delta z^2.$$

which uniquely determinates distance  $|\Delta s|$  between two points in space. Thus transition from some coordinate system to another one is carried out at fixed time, when location of points in space is fixed.

The basic result of brief consideration of concepts of time and space is the following. All natural processes under investigation are characterized by four independent variables: by absolute time  $t$  and three absolute Euclidean coordinates  $x, y, z$ . When transiting between two coordinate systems, the invariant values are the time interval  $\Delta t$  between two events at fixed point and the spatial interval  $|\Delta s|$  between two points in space at a fixed moment of time. Point of origin of the absolute time and origin of the absolute system of spatial coordinates and their directions one can choose arbitrary, basing upon convenience of studying of physical process. As we already noticed, in case of our Meta-Galaxy (visible Universe), it is convenient to consider the absolute coordinate system with the time and spatial coordinates origin located at the initial point of Big Bang.

**Experimental data.** We shall discuss some experimental confirmations of the Euclidean properties and of three-dimensionality of our space. The last careful experiments on small-scale fluctuations of the relict microwave radiation have shown its isotropy with precision up to  $10^{-4}$  K and have confirmed the Euclidean (plane) geometry of the Universe. Distribution of angular spectrum for power of fluctuations of relict radiation has the significantly expressed first peak, which corresponds to an angle of 1 degree that confirms the plane geometry of our Meta-Galaxy [76, 77].

Three-dimensionality of space is corroborated by validity of the law of reversed squares in the theory of gravitation, electrostatics and hydrodynamics. Spherically symmetrical vector field  $\bar{v}$  coursed by a source and depending on radial coordinate  $R$  only, is determined by the equation

$$\operatorname{div} \bar{v} = \frac{1}{R^2} \frac{\partial}{\partial R} (R^2 v_R) = 0$$

and has solution  $v_R = C / R^2$ , where  $C$  is a constant dependent on the source intensity.

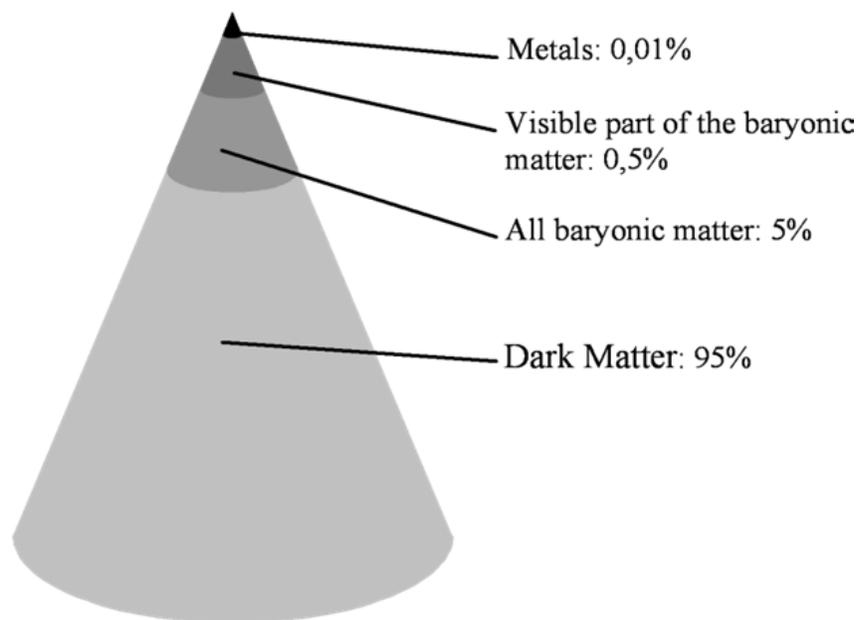
Area of the closed spherical surface of radius  $R$  is equal to  $4\pi R^2$  for the three-dimensional case only. The area of the hyper-spherical surface is proportional to other degrees of radius for spaces with other quantity of dimensions. Fulfillment of the Newton's gravitation law, Coulomb's law and law of the velocity field of a source and drain for incompressible fluid in our space (law of reversed squares) proves the property of three-dimensionality of the space.

### 3.3. Matter

*“So, there is nothing where the matter from Universe  
Could be disappeared and from where suddenly bursted.”  
Lucretius Carus “De Rerum Natura”[41]*

Materialization of concepts of time and space occurs with help of the real matter filling the space and changing with time. Basing upon the experimental facts, accumulated by the present moment, within the framework of the chapter, we shall also consider subbaryonic material substance along with the usual and customary baryonic matter.

**Structure of matter.** The percentage composition of the matter in our Meta-Galaxy (observable Universe) is graphically represented in figure 3. Numerous experimental data and a number of theoretical models reliably prove such structure. Metals compose approximately 0.01% of all matter in the Universe. Visible part of the baryonic matter makes about 0.5% only of the total amount of the registered matter. Estimation of all baryonic matter including invisible one (invisible planets such as Jupiter, black holes etc.), gives near 4% of the total amount. The remaining overwhelming part of the matter in the Universe, approximately 96%, is invisible, i.e. cannot be registered in optical range of electromagnetic radiation (as well as in other ranges: x-ray, ultra-violet, infrared, gamma and radio ones). In this respect, this matter in the Universe is called Dark Matter – DM. Approximately 22% of DM concentrated around the galaxies and their congestions in the shape of “spherical atmosphere” (galaxy halo). The rest of DM, about 74% of the total matter, as it is supposed, is rather uniformly distributed in free space of our Universe. Last years this part of DM is identified with Dark Energy – DE or with special Quintessence (see, for example [8]).



**Figure 3.** Composition of the matter in the observable Universe.

**Baryonic matter.** The main elementary components of the baryonic matter are usual protons and neutrons (baryons). Here we merely note that now baryonic matter in the Universe stay mostly (more than 95%) in gaseous (plasma) condition. About 70% of the baryonic matter in the Universe represented by the atomic hydrogen, about 25% is a share of helium. This baryonic matter is concentrated in hot gaseous congestions around galaxies. Theoretical description of dynamics of such hot congestions with good approximation can be conducted with help of methods of gas dynamics and plasma physics. The key moment here is definition of the state equation of the considered gaseous medium, adequate to the nature, especially at rather high temperature and pressure.

Dynamics of ordinary baryonic gaseous medium is described by three conservation laws – mass, momentum and energy. Boundary conditions and the state equation of the gaseous

medium close the task. As an example, we shall put here elementary equation of state for the perfect gas

$$p = \rho RT,$$

where  $p$  is the pressure,  $\rho$  is the density,  $T$  is the temperature,  $R$  is the universal gas constant. The characteristic speed of the disturbance propagation – speed of sound – is determined in adiabatic medium as

$$c^2 = \frac{dp}{d\rho} = \kappa \frac{p}{\rho} = \kappa \frac{k}{m} T,$$

$\kappa$  is the adiabatic index,  $k$  is the Boltzmann constant ( $k=R/N$ ,  $N$  is the Avogadro number),  $m$  is the mass of particles of the gaseous medium. Knowing speed of the disturbance propagation and medium temperature one can determine the mass of particles, composing the homogeneous gaseous medium. In the kinetic gas theory the state equation is obtained as a result of application of the Newton's laws.

### 3.4. Motion

#### Absolute motion

*“The absolute motion is movement of bodies from its absolute location to another one, relative motion - from relative to relative one ... Instead of absolute locations and motions one use relative; in every day’s business it does not make an inconvenience, in philosophical one it is necessary to abstract from the feelings.”*

I. Newton “The Beginnings” [71]

The absolute motion is considered as a movement of a body from one position to another in a selected absolute three-dimensional Euclidean space. As such absolute space we shall accept the recommended in 2.2 absolute Cartesian coordinates system, which point of origin is set to the initial point of Big Bang. The Galilean principle of relativity allows establishing unequivocal conformity between absolute and relative motion.

#### Axioms of motion

*“Axiomata sive Leges Motus.*

*I. Anybody remains at rest or at uniform and rectilinear motion, unless and until it is forced to change this state by the applied forces.*

*II. Variation of the momentum is proportional to the applied propulsion force and directed along the straight line of the force direction.”*

I. Newton “The Beginnings” [71]

Axioms of motion were precisely formulated by Newton and are explained in the introduction courses to the general physics.

**Newtonian principle of determinacy.** The Newtonian principle of determinacy consists of the following. Combination of positions and velocities of its points set the initial state of a system. It distinctively defines the subsequent motion of the system. In particular, the acceleration is uniquely determined

$$\frac{d\bar{v}}{dt} = \bar{F}(t, \bar{r}, \bar{v}).$$

We shall set some restrictions on the right part of equation using for this purpose the space-time properties. Homogeneity of time requires function  $\bar{F}$  to be dependent on the relative time  $\Delta t = t - t_0$  only, since the transformation of time shift (in other words, selection of the origin point of time  $t_0$ ) should not change the solution of the equation. Further, the fundamental property of homogeneity of space requires function  $\bar{F}$  to be independent on absolute coordinates. Invariance of the solution of the equation regarding the shift in space displays, that function  $\bar{F}$  may depend on relative coordinates  $\Delta \bar{r} = \bar{r} - \bar{r}_0$  only. Fundamental property of isotropy of space, i.e. the equality of all directions in space, imposes the following requirement on  $\bar{F}$

$$\bar{F}(t, G\bar{r}, G\bar{v}) = G\bar{F}(t, \bar{r}, \bar{v}),$$

where  $G$  is the orthogonal transformation of spatial coordinates and velocities. One more requirement to the right part of the equation follows from the properties of invariance with regards to the transition to the uniformly moving coordinate system. The Galilean principle of relativity and the first Newton axiom of motion formulated on its basis works here. Requirement of dependence of function  $\bar{F}$  on relative speed  $\Delta \bar{v} = \bar{v} - \bar{v}_0$  only follows from this principle. Because of this, the equation should be written in the form

$$\frac{d\bar{v}}{dt} = \bar{f}(\Delta t, \Delta \bar{r}, \Delta \bar{v}).$$

$$\bar{f}(\Delta t, G\Delta \bar{r}, G\Delta \bar{v}) = G\bar{f}(\Delta t, \Delta \bar{r}, \Delta \bar{v}).$$

The elementary examples of these equations are the equations of motion of a body of mass  $m$  under constant force  $\bar{f}$

$$m \frac{d\bar{v}}{dt} = \bar{f},$$

or equation of motion of the ideal (inviscid) fluid (gas)

$$\rho \frac{d\bar{v}}{dt} = -\text{grad } p,$$

where  $\rho$  is the density and  $p$  is the medium pressure etc.

Further when building the theoretical models of a nonlinear medium dynamics we shall always satisfy the listed requirements, which follow from the fundamental properties of space-time and the Galilean principle of relativity.

#### 4. Space energy & hidden mass boson

*Give me matter, and I will construct a world out of it!*

*Immanuel Kant (1755)*

*The Space Energy presents in our case the kinetic energy of HMB particles.*

##### 4.1. Dimensional analysis for hidden mass boson medium

We apply an ordinary physical dimensional analysis for free cosmic space in a standard way [51-54]. Executed dimensional analysis bases on measured values of the following quantities: the light speed  $c_0 = 2.998 \cdot 10^8$  m / s, the CMB temperature  $T_0 = 2.725$  K and the assessment of the critical density of the Universe  $\rho_0 \sim 10^{-26}$  kg/m<sup>3</sup>. It also uses three well-known constants: the Boltzmann constant  $k = 1.38 \cdot 10^{-23}$  kg (m/s)<sup>2</sup> /K, the gravitational constant  $G = 6.67 \cdot 10^{-11}$  Nm<sup>2</sup> /kg<sup>2</sup> and the Planck constant  $h = 6.63 \cdot 10^{-34}$  J s. Applying  $\pi$ -theorem by Buckingham [54], we construct the dimensionless parameters  $\pi$  and associated physically meaningful relationships.

The simplest dimensionless parameter  $\pi_1$ , connecting pressure, density and velocity, can be written as

$$\pi_1 = \frac{p}{\rho c^2} \sim 1$$

and allows an assessment of the "critical" pressure value

$$p_0 \sim \rho_0 c_0^2 = 10^{-9} \text{ Pa.}$$

In the case of an ideal "photon" gas with adiabatic constant  $\kappa = 4/3$  the speed of perturbations is defined as

$$c_0^2 = \kappa p_0 / \rho_0$$

and then we get  $p_0 = 1.4 \cdot 10^{-9}$  Pa. It should be emphasized that this positive value  $p_0$  can be interpreted as "critical" pressure of the Universe, determined by means of dimensional analysis in terms of its critical density  $\rho_0$ . We specifically focus on this fact to point out a fundamental difference from the negative pressure of the Universe [8], which is associated with the phantom dark energy that may influence the effect of "accelerating" expansion of the Universe.

A natural explanation for the apparent accelerating expansion of the Universe and a few other important items follow from the consideration of the dimensionless parameter  $\pi_2$  in the form

$$\pi_2 = \frac{kT}{mc^2} \sim 1$$

leading to the estimation of the particle mass  $m_0$  for the media with the temperature  $T_0$  and the disturbance propagation velocity  $c_0$

$$m_0 \sim \frac{kT_0}{c_0^2} = 4.25 \cdot 10^{-40} \text{ kg.}$$

An important conclusion of the analysis  $\pi_2$  is directly proportional of the velocity  $c_0$  to the square root of temperature  $c_0 \sim \sqrt{T_0}$ . In this connection we would like to get two remarks. The first is the possibility of a superluminal speed for disturbances in physical vacuum by  $T > T_0$ . In our case the limitation on weak propagation perturbations velocity is withdraw and the superluminal motion (without violation of the causality principle) is allowed. Here relevantly one gives the analogy with the classic gas dynamics, which allows the motion with supercritical (supersonic) velocities. The second remark is concerned the apparent accelerating expansion of the Universe. The Universe in the early time periods was hotter, had a higher temperature  $T_0$  and therefore higher value  $c_0$ . This fact naturally explains the observed luminosity week effect of distant supernovae.

It should be noted that the combination of dimensionless parameters  $\pi_1$  and  $\pi_2$  leads to a state equation of an ideal gas. We write the dimensionless parameter

$$\pi_3 = \frac{\pi_1}{\pi_2} = \frac{p}{nkT} \sim 1,$$

where  $n = \rho/m$  - the concentration of particles.

A more accurate assessment for  $m_0$  [78-80] gives

$$m_0 = 5.6 \times 10^{-40} \text{ kg.}$$

Further there is based this particle structure as a classic dipole with ultra-elementary charge near  $q_0 = 10^{-28} \text{ C}$ . Hence we can consider in detail a new complex elementary particle - Hidden Mass Boson (HMB). Dimensional analysis in the presence of a characteristic charge allows getting two character values: frequency (similar as Langmuir frequency in plasma) and Debye radius of screening. The last radius plays the key role in our study.

The dimensional analysis will be conducted, relying additionally on two parameters. Parameter  $\pi_4$  written as

$$\pi_4 = \frac{G\rho}{\omega^2} \sim 1$$

allows us to introduce the characteristic gravitational frequency  $\omega_0$ , the characteristic time period  $t_0 = 1/\omega_0$  and the characteristic linear dimension  $L_0 = c_0 t_0$  of our Universe

$$\omega_0 \sim \sqrt{G\rho_0} = 0.82 \cdot 10^{-18} 1/s$$

The value of the gravitational frequency is an analog of the plasma frequency, which characterizes the electric displacement of the negative charge from a positively charged layer. The exact value  $\omega_0$  is written (by an analogy with the definition of the plasma frequency) with a coefficient of proportionality  $\sqrt{4\pi}$ , i.e.  $\omega_0 = \sqrt{4\pi G\rho_0}$ .

We also consider the dimensionless fifth parameter

$$\pi_5 = \frac{hc}{kTl} \sim 1$$

allowing an assessment of the characteristic length  $l_0 \sim \frac{hc_0}{kT_0} = 5.3 \cdot 10^{-3}$  m. This quantity can be interpreted as estimation of the mean free path of particles for the physical vacuum, which has temperature  $T_0$ .

## 4.2. Elements of thermodynamics and statistical mechanics

An interesting result of dimensional analysis is the presence of particles with mass  $m_0$  in a free radiating space (the physical vacuum) with the equilibrium temperature  $T_0$  and the disturbance velocity  $c_0$ . The zero law of thermodynamics allows introducing a temperature as the state parameter. The temperature  $T_0=2.725$ K characterizes of cosmic background microwave equilibrium radiation state. By using a simple gas kinetic approach we can find the refined value of the mass of these particles. The averaged kinetic energy of random motion of particles is

$$E = \frac{m_0 v_{av}^2}{2} = \frac{3}{2} kT_0 = m_0 \frac{3 R_y T_0}{2 m_0 N_A} = \frac{9}{8} m_0 c_0^2,$$

where the  $k = R_y / N_A$  Boltzmann constant,  $R_y$  - the universal gas constant,  $N_A$  - the Avogadro's number. From this relation we obtain for HMB

$$m_0 = \frac{4}{3} \frac{kT_0}{c_0^2} = 5.6 \cdot 10^{-40} \text{ kg} \cong 3 \cdot 10^{-4} \text{ eV}.$$

We calculate the gas constant  $R = R_y / m_0 N_A$  and specific heat capacity  $c_v$  and  $c_p$  in the assumption of ideal gas with adiabatic index  $\kappa=4/3$ :

$$R = \frac{k}{m_0} = 0.25 \cdot 10^{17} \text{ J / kg K}, \quad c_v = 0.75 \cdot 10^{17} \text{ J / kg K}, \quad c_p = c_v + R = 1 \cdot 10^{17} \text{ J / kg K}.$$

Further, following the traditional thermodynamics of ideal gas for radiation medium, we can write the classical state equation

$$p = \rho RT$$

or

$$p = (\kappa - 1)\rho e,$$

where  $e = c_v T$  - the specific internal energy.

An important next step is to postulate the structure of radiation particles, which allows explaining the large number of effects and phenomena observed in the physical vacuum. Following [79-80], we consider a whole electrically neutral particle in the form of a dipole consisting of two parts with positive and negative charge equaled to about  $5 \cdot 10^{-29}$  Coulomb. Thus, we actually introduce the new mass medium of bosons - Hidden Mass Boson (HMB) and can apply to its analysis well developed methods of statistical mechanics and thermodynamics.

Let us explain in more detail, why the mass particle radiation of the physical vacuum is taken in our analysis in the form of the dipole, called hereafter by the hidden mass boson. First, in this case the issue of physical vacuum polarization is extremely clear. In an external electric field orientation of the HMBs takes on power lines of the electric field, partly compensating for the external field. Thus, we obtain a clear physical interpretation of the Maxwell's displacement current in free space. Further, the energy flux vector of the electromagnetic field - Umov - Poynting vector indicates the direction of the HMB polarization under the influence of an external electromagnetic field. In particular, when charging of the capacitor without insulator between the plates HMBs are moving from outer space in between the capacitor plate space, providing in this case, the displacement current. Another important process of electron-positron pair birth in the physical vacuum in the collision of two sufficiently intense electromagnetic pulse [81] should be interpreted as a break in a certain (sufficiently large) number of dipoles - HMB followed by concentration of their parts of the same sign of charge at the centers of the electron and positron under the influence of forces including non-electromagnetic nature (e.g., gas dynamics, gravity, etc.). When implementing this scenario, the HMBs will determine the mass of the birth of baryonic matter in the physical vacuum.

Substantiated to some extent chosen postulated HMB structure, we proceed to the methods of statistical mechanics. We consider the important question of the consistency of our work findings to well-known basics and conclusions of statistical physics and thermodynamics of a boson gas and its special case - a photon gas with zero rest mass of photons. Below we demonstrate the absence of such contradictions.

First of all, we write the state equation for gases obeying Bose statistics and Fermi statistics. Here, the dimensionless parameter can be written [82, 83]

$$\pi_3 = \frac{p}{nkT} = 1 \mp \frac{1}{2^{5/2}} \lambda_0 + \dots,$$

where the signs  $\mp$ , respectively, for the Bose and Fermi gases, as well  $\lambda_0^{-1} = (2\pi mkT)^{3/2} / h^3 n$  - the statistical sum per particle. The second and higher terms in the right side of the above formula are quantum statistical origin. This series expansion is valid for values  $\lambda_0 < 1$  or to values  $n < (2\pi mkT)^{3/2} / h^3$ . The magnitude  $h / (2\pi mkT)^{1/2}$  is the length of the thermal de Broglie wavelength, and the value  $h / (3mkT)^{1/2}$  corresponds to the thermal energy of the particle  $3/2kT$ . Thus the Bose statistics in the usual manner is applied to the entered us with dimensional analysis and thermodynamics of the HMB gas. For future study the condensation state of the HMB gas on the lowest temperature and high pressure is also very important item.

As for the well-known theory of blackbody radiation, in our approximation it requires some revision, which consists in passing from the linearized formulation of the problem to a fully nonlinear formulation. The essence of this transition can be clearly illustrated by the linearized theory of acoustics and the original theory of the nonlinear gas dynamics. It seems very clear that in a limited gas volume it is possible to describe the it's state in the acoustic approximation using the equation for the acoustic pressure perturbation

$$\nabla^2 p - \frac{1}{c^2} \frac{\partial^2 p}{\partial t^2} = 0$$

Based on this description, we can then determine an acoustic sound radiation from a closed cavity and the radiation field in the outer vicinity of the limit volume. In this description one can calculate the acoustic field in a gas without going into details of what the gas medium consists of a mass of individual particles. However, to calculate the real total pressure in the limited volume the initial nonlinear laws of gas dynamics are required (of them will be discussed in the section 4.4).

A similar situation occurs with the thermal radiation of a blackbody. Currently, in the approximation of massless photon equilibrium radiation field is described by the linear wave equation [82]

$$\nabla^2 E - \frac{1}{c^2} \frac{\partial^2 E}{\partial t^2} = 0.$$

The radiation field is represented by a set of simple harmonic oscillators with discrete spectrum of energy. As a result of the energy spectrum of equilibrium radiation gives the Planck formula

$$U_\nu = \frac{8\pi h\nu^3}{c^3} \frac{1}{e^{\frac{h\nu}{kT}} - 1}$$

Calculations using this formula are in full agreement with the experimental far field radiation, where the linearized theory actually works (as in acoustics case). However, in the

case of massive bosons radiation the study of the thermal process in limited volume should be with help of nonlinear formulation, which we detail below.

To conclude this section we emphasize that known values  $p_0$  and  $\rho_0$  characterize the state of the photon gas in the physical vacuum of space (in the vicinity of the Earth and solar system) with the measured temperature CMB  $T_0 = 2,725$  K. The pressure  $p_0$  is the direct pressure of the HMBs medium in the region (source) at  $T_0$ . This value differs on a factor  $c_0=3 \cdot 10^8$  m / s from the linearized values in a far field, which is calculated by methods of classical electrodynamics. It should specify the complete analogy with the usual gaseous medium in which acoustic pressure away from the noise source is different from the pressure at the source (this difference is also characterized by a factor containing the magnitude of the velocity of disturbance propagation, in this case - the sound speed  $c$ ).

Further consideration of the influence of thermal radiation effects environment will be carried out within the framework of two-component model of the emitting gas with the mass of the photon component [84].

### 4.3. Modified Maxwell equations in free space

In the medium of physical vacuum being examined the longitudinal and transverse waves will propagate in the electromagnetic field. The system of linear equations, describing the propagation of electromagnetic disturbances can be written in the form [40]

$$\begin{aligned}\frac{\partial \mathbf{E}}{\partial t} - c \operatorname{rot} \mathbf{H} + c \operatorname{grad} q_e &= 0, \\ \frac{\partial \mathbf{H}}{\partial t} + c \operatorname{rot} \mathbf{E} + c \operatorname{grad} q_m &= 0, \\ \frac{\partial q_e}{\partial t} + c \operatorname{div} \mathbf{E} &= 0, \\ \frac{\partial q_m}{\partial t} + c \operatorname{div} \mathbf{H} &= 0.\end{aligned}$$

With the purpose of longitudinal waves modeling into tradition system of electrodynamics equations of a free space, the scalar field  $q_e$  and  $q_m$  were introduced and that represents the density of force lines of electric and magnetic field. The first term in the first equation of the system is a time change of  $E$  and the displacement current in vacuum.

The system describes the propagation of all parameters of disturbances with the same speed  $c$ . It is easy to prove, differentiating the first two equations with respect to  $t$ :

$$\begin{aligned}\frac{\partial^2 \mathbf{E}}{\partial t^2} + c^2 \operatorname{rot} \operatorname{rot} \mathbf{E} - c^2 \operatorname{grad} \operatorname{div} \mathbf{E} &= 0, \\ \frac{\partial^2 \mathbf{H}}{\partial t^2} + c^2 \operatorname{rot} \operatorname{rot} \mathbf{H} - c^2 \operatorname{grad} \operatorname{div} \mathbf{H} &= 0,\end{aligned}$$

that, by using the formula of vector analysis

$$\Delta A = \text{grad div} A - \text{rot rot} A$$

leads to the waves equations for the changes  $E$  and  $H$

$$\frac{\partial^2 E}{\partial t^2} - c^2 \Delta E = 0, \quad \frac{\partial^2 H}{\partial t^2} - c^2 \Delta H = 0.$$

The changes of scalar field  $q_e$  and  $q_m$ , as well as scalar and vector potentials of  $E$  and  $H$  can be also lead to the wave equations.

The system of linear equations describes the propagation with equal velocities both the longitudinal waves (the wave of compression and rarefaction) and the transverse wave (share wave) in a homogeneous isotropic space. At the same time, the modeling of longitudinal wave is provided by the introduction additionally of the scalar fields  $q_e$  and  $q_m$  to the system Maxwell equations. In this connection, we can call the scalar fields  $q_e$  and  $q_m$  as fields of density (force lines), connecting with fields  $E$  and  $H$ . In principle, it is not difficult to examine the case when propagation velocities of longitudinal and transverse waves in the electromagnetic field are different.

#### 4.4. Conservation laws for two component gaseous medium

Here is a complete system of conservation laws for two component model of gas-like environment, taking into account the HMB medium (radiation) component. All used parameters will be denoted in the traditional way. Attributing them to the corresponding indices:  $g$  - for the gas component,  $f$  - for the radiation component (e.g. density  $\rho_g$  and  $\rho_f$ ).

The total value of the density, pressure and internal energy will be denoted without an index.

The laws of conservation of mass, momentum and energy in the divergence form for each component have the form [84]

$$\begin{aligned} \frac{\partial \rho_g}{\partial t} + \text{div}(\rho_g \bar{V}_g) &= q_g, \\ \frac{\partial \rho_f}{\partial t} + \text{div}(\rho_f \bar{V}_f) &= q_f, \\ \frac{\partial \rho_g \bar{V}_g}{\partial t} + \text{div}(\rho_g \bar{V}_g (\bar{V}_g \cdot \bar{n})) + \text{grad } p_g &= r_g, \\ \frac{\partial \rho_f \bar{V}_f}{\partial t} + \text{div}(\rho_f \bar{V}_f (\bar{V}_f \cdot \bar{n})) + \text{grad } p_f &= r_f, \\ \frac{\partial \rho_g e_g}{\partial t} + \text{div}(\rho_g e_g \bar{V}_g) + p_g \text{div} \bar{V}_g &= \text{div}(K_g \text{grad} T_g) + c_{fg}(T_f - T_g) + Q_g, \\ \frac{\partial \rho_f e_f}{\partial t} + \text{div}(\rho_f e_f \bar{V}_f) + p_f \text{div} \bar{V}_f &= \text{div}(K_f \text{grad} T_f) + c_{fg}(T_g - T_f) + Q_f \end{aligned} \quad (1)$$

This system of equations is written for the thermal conductivity of the gas and radiation components (the first terms on the right hand side,  $K_g$  and  $K_f$  - the thermal diffusivity of the gas and radiation components, respectively). The second terms on the right sides of two last equations characterize the energy exchange between the gas and radiation components. The last terms,  $Q_g$  and  $Q_f$  are supplementary sources of energy, taking into account the availability of additional channels of energy exchange (e.g., in the case of registration of chemical reactions, etc.). The system (1) is closed by equations of state for the gas and radiation components. Using this set, one can give a natural interpretation of the growth of entropy in compression shocks, where a part of the kinetic energy of the gaseous component in the shock turns into heat. When the velocity  $V_g$  drastically decreases, a part of the energy from polarized molecule space goes into the radiation component and this part of energy is dissipated due to heat conduction.

Of course, a solution of this system in general form involves considerable difficulties, because we need to specify the value of the exchange heat coefficient  $c_{fg}$  between the phases. Substantial simplification can be achieved by considering the approximation of one velocity and one temperature movement phase in the presence of a thermodynamically equilibrium

$$V_g=V_f=V; \quad T_g=T_f=T.$$

We also assume that there are no external sources of mass and momentum in this region of flow and mass transfer between phases:

$$q_g=q_f=0; \quad r_g=r_f=0.$$

Then, following [85, 86], we represent the continuity equation of each phase in the form

$$\frac{1}{\rho_g} \frac{d\rho_g}{dt} + \text{div}\bar{V} = 0,$$

$$\frac{1}{\rho_f} \frac{d\rho_f}{dt} + \text{div}\bar{V} = 0$$

or

$$\frac{d}{dt} \left( \ln \frac{\rho_f}{\rho_g} \right) = 0.$$

The last equality says the preservation of values

$$\alpha = \rho_f / \rho_g \tag{2}$$

along the stream lines, and if we assume that the initial time the density ratio is constant and independent of the coordinates, the equation (2) is valid at any point of considered medium.

We write total conservation laws for both components of the medium. Adding first two and second two equations in the system (1) we obtain, taking into account our assumptions, usual equations of a continuity and a motion for one-component medium

$$\begin{aligned}\frac{\partial \rho}{\partial t} + \operatorname{div}(\rho \bar{V}) &= 0, \\ \frac{\partial \rho \bar{V}}{\partial t} + \operatorname{div}(\rho \bar{V}(\bar{V} \cdot \bar{n})) + \operatorname{grad} p &= 0.\end{aligned}$$

Slightly change the total energy equation. Adding the last two equations in (1) we obtain

$$\begin{aligned}\frac{\partial}{\partial t} \left[ (c_{vg} \rho_g + c_{vf} \rho_f) T \right] + \operatorname{div} \left[ (c_{vg} \rho_g + c_{vf} \rho_f) T \bar{V} \right] + p \operatorname{div} \bar{V} &= -\operatorname{div} W + Q, \\ -W &= K_g \operatorname{grad} T_g + K_f \operatorname{grad} T_f, \quad Q = Q_g + Q_f.\end{aligned}$$

In order to give the energy equation the usual form, we transform the expression

$$N = c_{vg} \rho_g + c_{vf} \rho_f,$$

as

$$\begin{aligned}N &= c_{vg} \rho_g \left( 1 + (c_{vf} \rho_f) / (c_{vg} \rho_g) \right) = c_{vg} \rho / (1 + \alpha) \left( 1 + (k_g - 1) / (k_f - 1) p_f / p_g \right) = \bar{c}_v \rho, \\ \bar{c}_v &= c_{vg} \left( 1 + (k_g - 1) / (k_f - 1) p_f / p_g \right) / (1 + \alpha), \quad k = c_p / c_v.\end{aligned}$$

Recall that, according to (2)  $\alpha = \rho_f / \rho_g$ , constant along streamlines. Consequently, when  $T_f = T_g$ , the ratio  $p_f / p_g$  is constant along streamlines.

Similarly, we transform the equation of state for the total system

$$p = \bar{R} \rho T, \quad \bar{R} = R_g \left( 1 + p_f / p_g \right) / (1 + \alpha).$$

The energy equation with right term  $-\operatorname{div} S$ , where the radiation flux  $S = \sigma T^4$ , is often used in the simulation of the radiate flows. For further analysis with using of this approximation we obtain the following system, describing the equilibrium one velocity flow in the presence of radiation effects

$$\begin{aligned}\frac{\partial \rho}{\partial t} + \operatorname{div}(\rho \bar{V}) &= 0, \\ \frac{\partial \rho \bar{V}}{\partial t} + \operatorname{div}(\rho \bar{V}(\bar{V} \cdot \bar{n})) + \operatorname{grad} p &= 0, \\ \frac{\partial}{\partial t} \bar{c}_v T + \operatorname{div} \bar{c}_v T \bar{V} + p \operatorname{div} \bar{V} &= -\operatorname{div} \sigma T^4, \\ p &= \bar{R} \rho T.\end{aligned}$$

Obviously, when  $\rho_f = 0$  we obtain the ordinary system of gas dynamics equations for one component radiation medium. Further we present some examples of our model applications.

## 5. Space energy & grand unified theory

*"Space Energy is conserving,  
Space Entropy is growing".*

*E. Fermi*

A classical unified theory of electromagnetic, weak and strong interaction, electrovalence linkages and antimatter is built coming from our Space Energy simulation. The theory bases on Hidden Mass Boson in form of a classic dipole and the Debye length of polarized spaces. These items are the background of our Grand Unified Theory (GUT).

### 5.1. Debye spheres of electron and proton – the background of GUT

"The electron polarizes vacuum, allegedly attracts to itself virtual positrons, and repulses virtual electrons". So, in particular, the vacuum polarization phenomena are described in monograph [89]. In full correspondence with similar experimentally confirmed polarization of near electron space is found the stated below mathematical model of electron and proton structure. Here we shall imply only under "virtual" electron and positron a real polarized gaseous structure of DM dipole particles (HMBs), from which, as already noted, electron-positron pairs might be generated.

Within the framework of considered approximation one can formulate specific equation system similar the gas dynamics model with electric charge presence, as the two fluid hydrodynamic plasma model. For steady state from mentioned models we can lightly derive equations, describing particle electricity potential and concentration distribution in polarized Debye spaces of electron, positron, proton and anti-proton.

First of all we would like to obtain the estimation of Debye spheres for electron. A Debye sphere is a volume of influence, outside of which charges are sufficiently screened. In our simulation a Debye sphere is formed with a pressure field presence of HMB gaseous medium. For steady state a two fluid hydrodynamic model [90, 91] may be expressed by equation system (in the SI units)

$$\begin{aligned} \frac{\nabla p_{\pm}}{n_{\pm} m} &= \mp \frac{1}{4\pi\epsilon_0} \frac{e}{m} \nabla \varphi, \\ \Delta \varphi &= -4\pi e(n_+ - n_-), \\ p_{\pm} &= n_{\pm} kT, \end{aligned} \quad (3)$$

where  $p_{\pm}, n_{\pm}$  - pressure and concentration of positive and negative of HMB components, which have the same temperature  $T$ ,  $e$  - elementary charge of HMB dipoles. From (3) the equation of electric potential  $\varphi$  for polarized space in non-dimensional form is written in rather simple form

$$D^2 \Delta \varphi = 2sh\varphi. \quad (4)$$

Here potential  $\phi$  is referred to its value  $\phi_0 = 4\pi\epsilon_0 T$ ,  $D = \text{sqrt}(\epsilon_0 kT / q^2 n_0)$  - the Debye radius (length),  $n_0$  - typical HMB boundary concentration. For concentration of HMB particle charge component in polarized space we have from (3) the Boltzmann distribution (in non-dimensional form)

$$n_{+,-} = n_0 \exp(\mp\phi)$$

The Debye length for electron in HMB medium can be calculated using its mass  $m_e=9.1\cdot 10^{-31}\text{kg}$ , charge  $q_e=1.6\cdot 10^{-19}\text{C}$  and Compton's length  $\lambda_e=2.43\cdot 10^{-12}\text{m}$ . The effective electron volume, which contains the most part of its mass, may be estimated as

$$V_e = 4/3\cdot\pi\cdot\lambda_e^3 = 0.601\cdot 10^{-34}\text{ m}^3.$$

Our great assumption is the distribution of whole electron mass between the point center (with the smallest point radius near  $10^{-17}$  -  $10^{-18}$  m, where the whole electron charge is concentrated) and other volume  $V_e$ . Here we assume that the electron mass is dividing near half. When HMB averaged concentration  $n_e$  in this volume is

$$n_e = (m_e/2)/V_e/m = 1.35\cdot 10^{43}\text{ 1/m}^3.$$

Further we provide the estimation of HMB dipole charge  $q$ . The number of charge particles in the electron center  $N_e=(m_e/2)/(m/2)=1.62\cdot 10^9$  and  $q=q_e/N_e=0.99\cdot 10^{-28}\text{C}$ . Now we can calculate the Debye electron length of charge screening (by  $T=2.725\text{K}$ )

$$D_e = \text{sqrt}(\epsilon_0 kT/q^2/n_e) = 0.5\cdot 10^{-10}\text{m}.$$

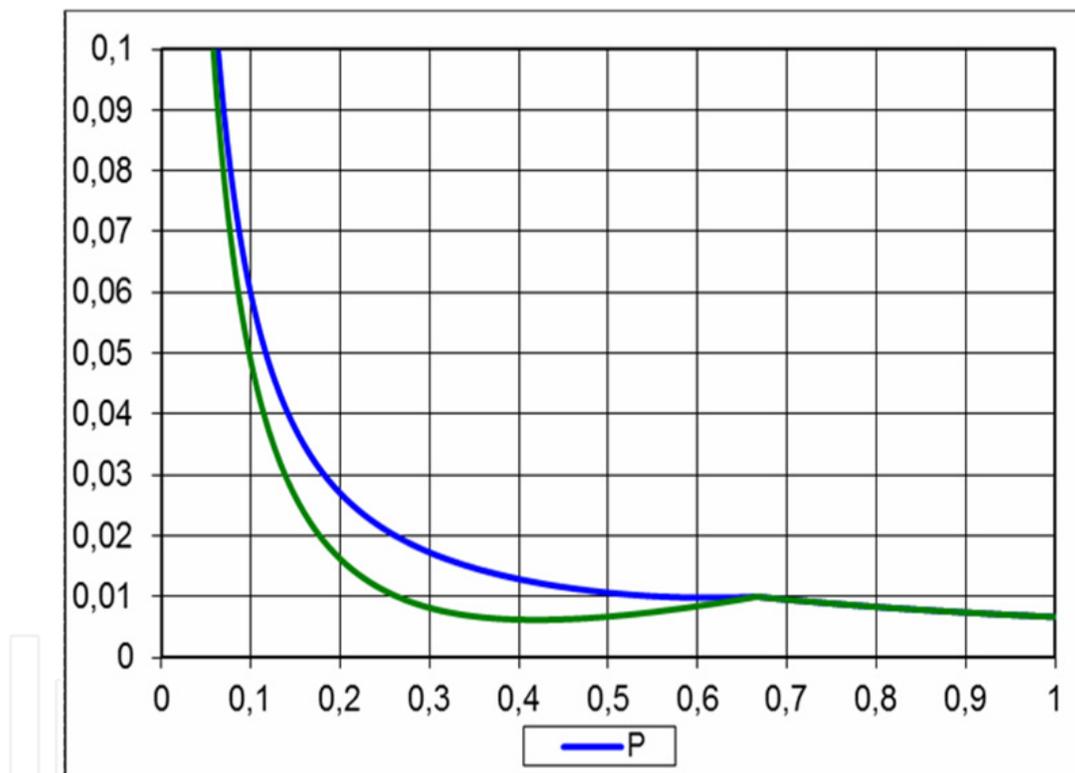
In the spherical symmetric case with single spatial coordinate-radius  $r$  we come from (4) to relationship

$$\frac{D_e^2}{r^2} \frac{d}{dr} \left( r^2 \frac{d\phi}{dr} \right) = 2sh \phi$$

We shall bring typical solutions of the last equation for polarized electron space (Figure 4). A principal important particularity of distribution presented is potential pit and barrier on external border of polarized space with distribution  $\phi(r)$  break. Herewith an induced negative electric charge is concentrated on external border, induced by charged electron core during polarizations of its "fur coat". The results presented are valid due to charge symmetry also for description of polarized positron space structure (when changing potential sign on opposite). The scheme of polarized electron space is shown on Figure 5.

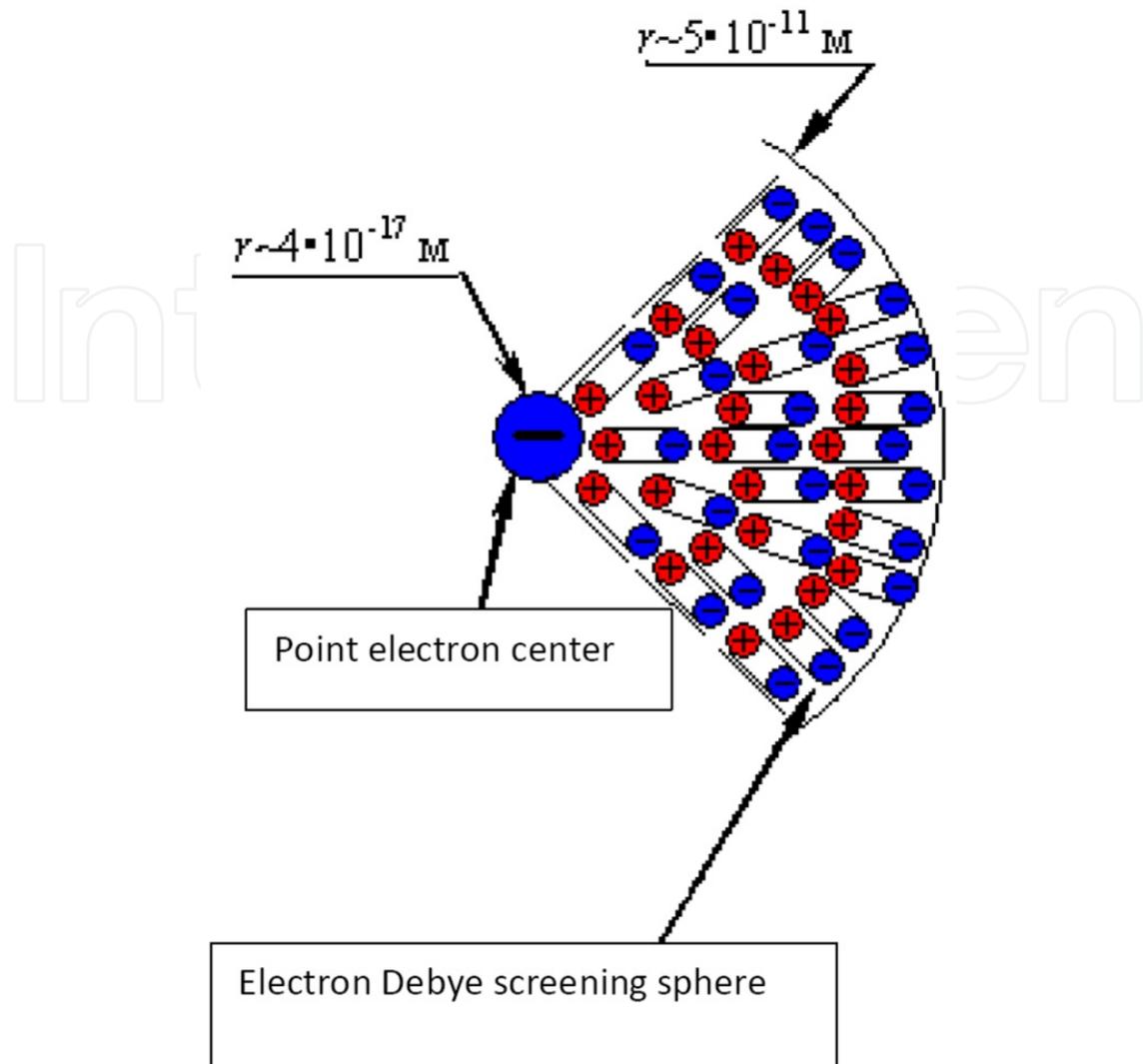
Now consider possible building on the same principles of proton and antiproton model. In analogy with electron we suppose that the entire positive proton charge is concentrated in its center, having an estimated size, like electron core size of order  $10^{-17}$  m. This central nucleus is spherical "droplet" surrounded polarized by HMB in "fluid" aggregate condition. The droplet size defines a typical known proton nuclear size (about  $0.8\cdot 10^{-15}$  m), where

practically its entire mass concentrates. The concentration of HMB in the fluid droplet is near  $10^{57}$  and the Debye screening radius near  $0.8 \cdot 10^{-15} \text{m}$ . The HMB fluid droplet provides the effective Debye screening and plays the key role in weak and strong interactions. Around proton nuclear droplet there is polarized spherical HMB space in gaseous aggregate condition, similar to polarized positron space. Modeling structure of two-layer polarized proton space is executed by integrating equation (4) for electric potential with the use of different state equations (for liquid and gaseous HMB phases). Examples of similar solutions by nature repeat solutions shown on Figure 4. And again basically important here is the presence of two potential pits and two barriers at  $r \approx 0.8 \cdot 10^{-15} \text{m}$  and  $r_0 = D_e \approx 5 \cdot 10^{-11} \text{m}$ . The structure built of proton with partial screening of its charge by two-layer polarized space is steady. Due to charge symmetry the antiproton structure repeats proton structure (with corresponding change of potential sign and others). The scheme of polarized proton space is shown on Figure 6.



**Figure 4.** Potential distribution in electron screening space for two D

The model of hydrogen atom consists of proton with concentrated in its center positive charge and two-layer HMB polarized space in fluid (up to  $0.8 \cdot 10^{-15} \text{m}$ ) and gaseous aggregate conditions and having an electron situated in steady stationary state on polarized space external surface ( $r_0 = D_e = 0.5 \cdot 10^{-10}$ ). Herewith for ensuring electron stationary condition in atom there is no need to introduce additional quantum postulates. This condition is provided by potential distribution in the electron and proton models built. The scheme of polarized hydrogen atom space is shown on Figure 7. The potential distribution in the hydrogen atom is present on Figure 8.



**Figure 5.** Scheme of electron screening space

## 5.2. Physical model of van der Waals polarized atom spheres

The presence of real existing polarized atom space and their forms close to spherical (van der Waals spheres as Debye screened spheres) is validated by methods of crystal-chemistry and scanning probe microscopy. By means of tunnel microscope needle one can manipulate separate spherical atoms, move them on surfaces, build 3D figures, etc. Atom shape presentation as van der Waals spheres is now broadly used method when studying substance physical-chemical properties.

The previous section offers models of polarized screened spaces partly shielding central concentrated electrical charges that enable demonstrative physical interpretation of van der Waals atom spheres. These spheres are in essence external borders of polarized spaces filled with HMB dipoles Coulomb interaction bound. On such spherical borders with local concentrated induced charges might be stationary placed concentrated charges of another sign (example: hydrogen atom from article previous paragraph).

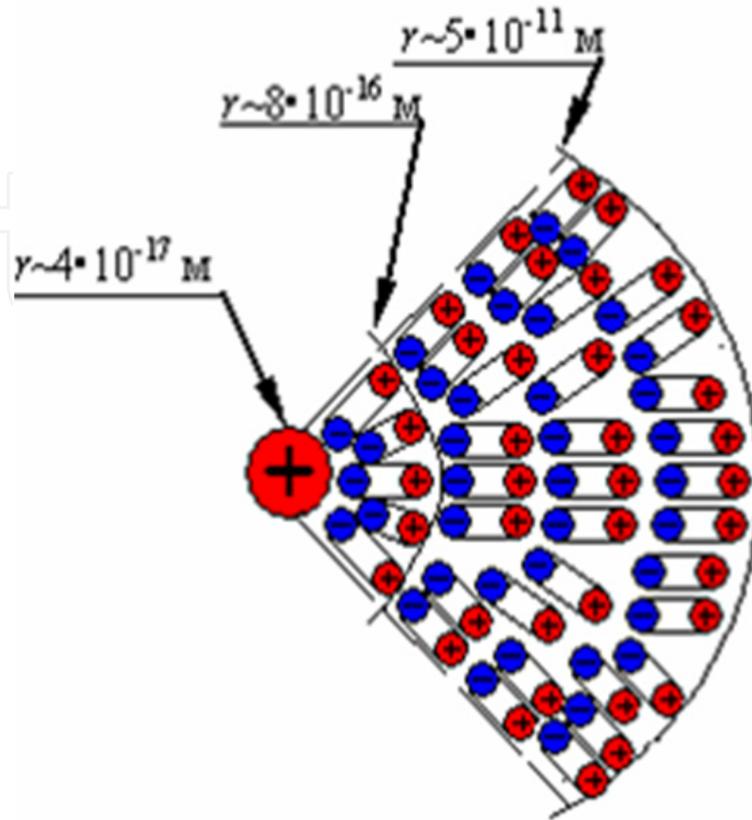


Figure 6. Scheme of proton screening two layer space

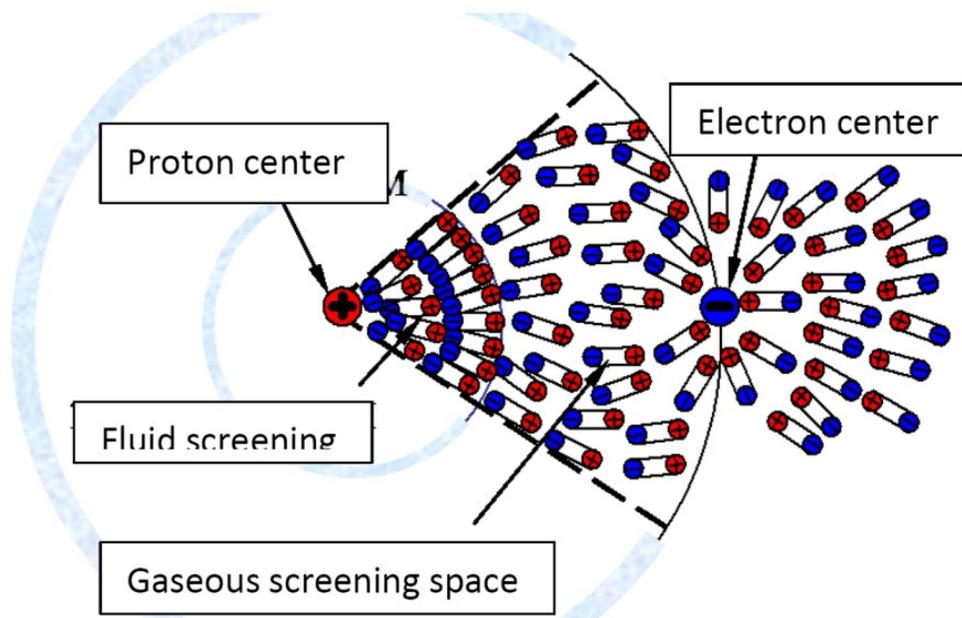
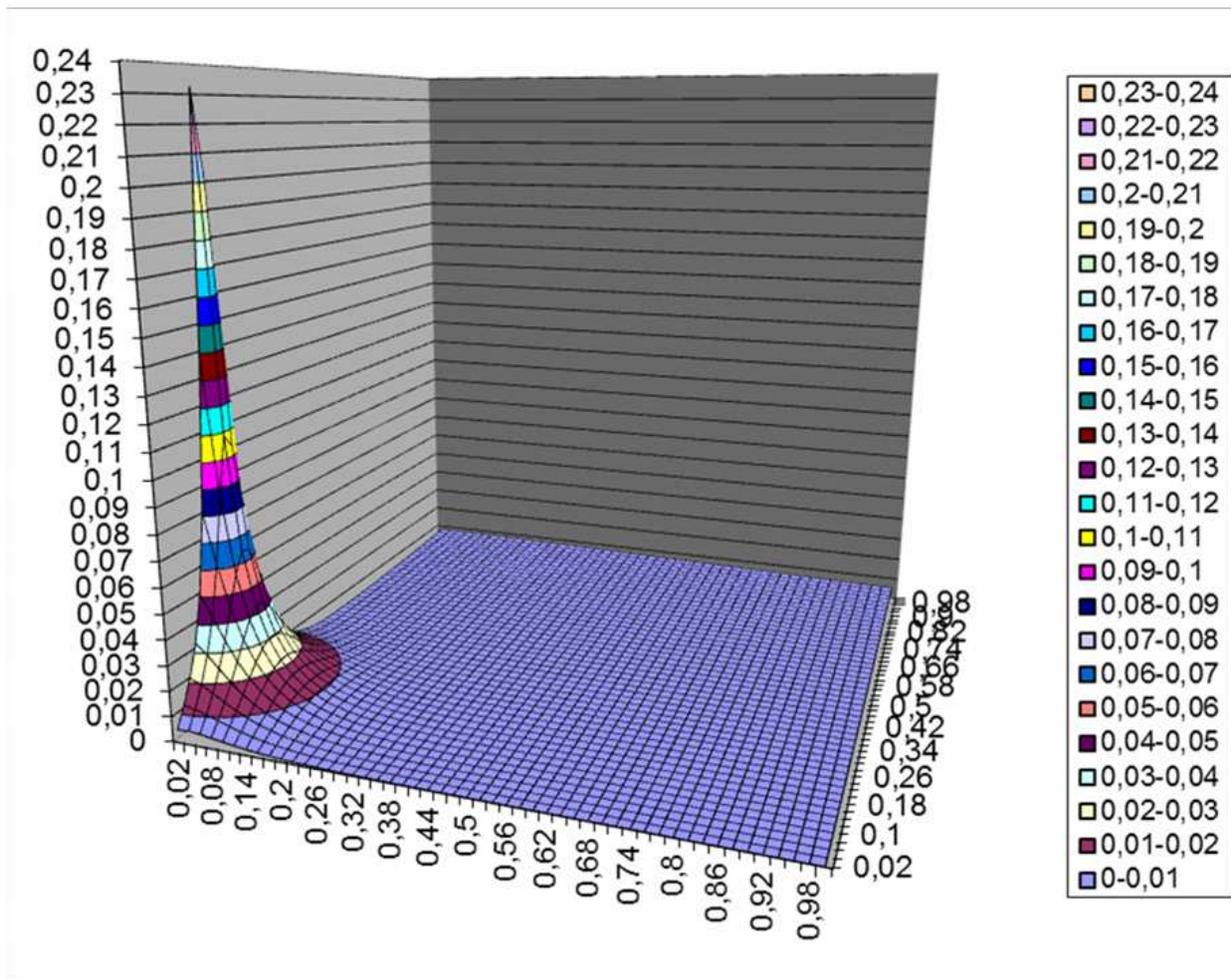


Figure 7. Scheme of hydrogen atom



**Figure 8.** Numerical solution for potential distribution inside hydrogen atom

Possible stationary steady electron position on van der Waals spheres brings about a model of atom electronic shell with STationary ELection (STEL models). Electronic shells of spherical shape are equidistant to nucleus centre at distances accordingly  $1r_0, 2r_0, 3r_0, 4r_0$ , etc. (natural row coefficients 1, 2, 3, 4... show, as accepted, main quantum number). The first shell area  $4\pi r_0^2$  is fully occupied by 2 stationary electrons; they rather tightly cover nearly whole area by their own polarized spaces. The following three shells area  $4(4\pi r_0^2)$ ,  $9(4\pi r_0^2)$  and  $16(4\pi r_0^2)$  can be occupied by less 8, 18, and 32 stationary electrons (double square of main quantum number); also tightly covering by their own polarized spaces nearly whole disposable area of corresponding shell. The rule stated defines maximum possible electrons number on any electronic shell (its "thick packing"), however electrons number on external shells at once may not reach its maximum value.

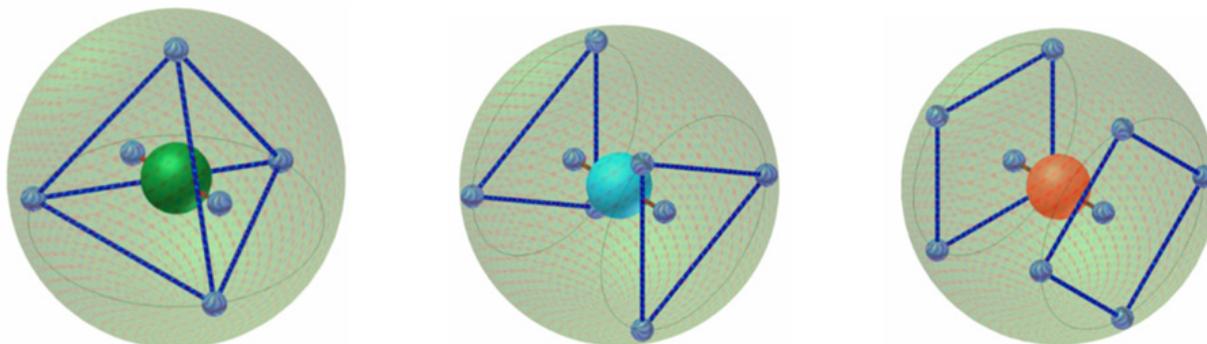
Number of ordinal atom element increasing and its nucleus positive charge growing under action of increasing Coulomb forces, the electron shells compress ( $r_0$  decreases) that fully complies with experimental data on atom sizes of different chemical elements. Heat expansion of electronic shells (including external van der Waals spheres) on linear law is described by corresponding solutions change of equation (4) for polarized atom space when

changing Debye radius  $D = (kT\varepsilon_0 / n_0 q^2)^{1/2} \sim T$  (since typical gaseous HMB concentration  $n_0$  at similar pressure  $p_0$  is inversely proportional to temperature  $T$ ).

### 5.3. STEL model for atoms and molecules

Let us give some examples of typical atomic structures within the framework of STationary Electron (STEL) model. Begin with helium atom and its first electronic shell filled by two electrons. There are two protons and two neutrons in the center of helium atom. On surfaces of first polarized space – helium nucleus border ( $r \sim 10^{-15}$  m) there are two electrons in steady state due to total potential distribution. The DM polarized space in gaseous condition is situated around nucleus on the space external shell ( $r \sim 0.5 \cdot 10^{-10}$  m) with two electrons in steady state. This first electronic shell is tightly "filled" due to the described structures of electron polarized space (also  $r \sim 0.5 \cdot 10^{-10}$  m). Each electron occupies about half spherical shell around helium atom.

The next is a carbon atom. Its external shell has 4 electrons located in tetrahedral tops (traditional direction of valence links, Figure 9). Oxygen atom on external shell contains 6 electrons. The least total potential energy of these electrons is provided by their location in two triangles tops in parallel planes and turned to each other by angle  $60^\circ$  (so called triangle anti-prism, Figure 9).

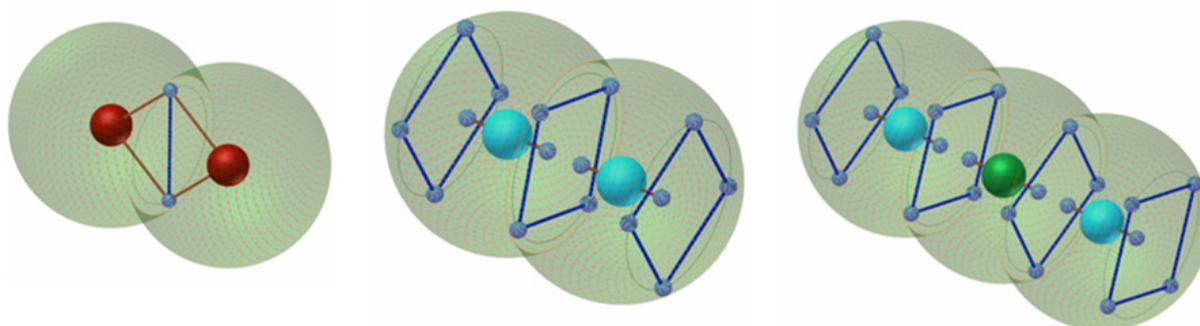


**Figure 9.** Structures for carbon, oxygen, and neon atoms

An inert gas neon atom has on external shell 8 electrons. The least total potential energy of these electrons forms at their location in square tops turned by angle  $45^\circ$  (square anti-prism, Figure 9). Similar structure to carbon, oxygen, and neon atoms is for atoms of silicon, sulphur, and argon accordingly with the same location of 4, 6, and 8 electrons on the third external shell. One can uncomplicated similar way reproduce stationary electron location on completely filled third shell with 18 electrons of 4 period (5 rows) elements and fourth shell with 32 electrons of 6 period elements of the Mendeleev table.

The illustrated application of STEL model for electron shells description in some features repeats the known Lewis octets. An important novelty to model STEL is electrons location in anti-prism tops (for oxygen, neon, sulphur, and argon) providing minimum value of total potential energy of external electrons.

Existence of DM polarized spaces of electron, proton, and atomic nucleus allows description from general positions through Coulomb interaction of any available molecular linkages as stationary deterministic structures of shell electrons and nucleus. Here we also use the model STEL. The simplest hydrogen  $H_2$  molecule presents a 2D quadrangle, in opposite tops of which there are two protons and two electrons (Figure 10). These perimeter concentrated charges are located at distances about Debye radius and partly shielded by HMB polarized space. Potential distribution in polarized hydrogen molecule space might also be found by integrating equation (4). Here the covalence link presents a pair of stationary electrons (not moving on orbits).



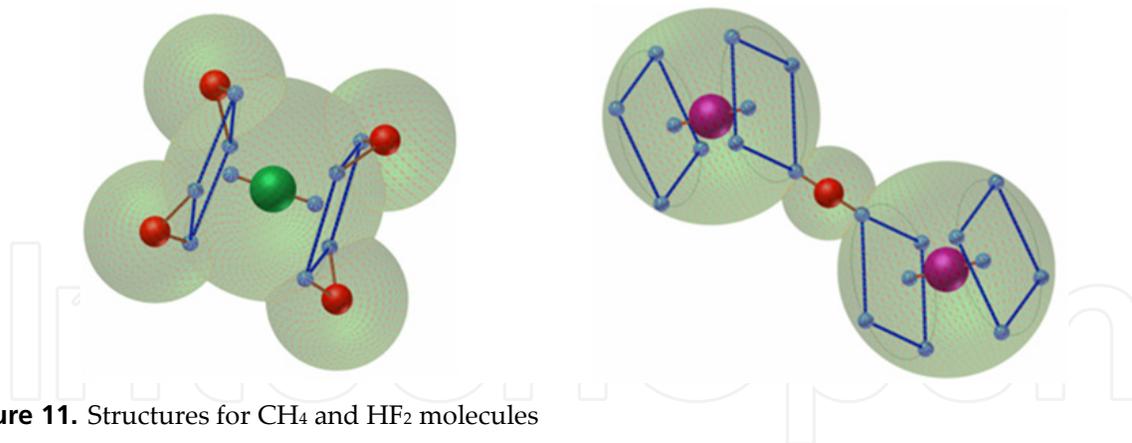
**Figure 10.** Structures for  $H_2$ ,  $O_2$  and  $CO_2$  molecules

For geometric presentation and physical description of molecular links with participation of elements of second and third periods of Mendeleev table we return to modified Lewis cubic structures and his electron octets. Instead of perfect cubes with electrons in their tops we have square anti-prisms. Bring some typical examples. In asymmetrical water molecule each hydrogen atom is connected by covalence link (pair of socialized electrons) with oxygen atom in neighboring tops of square anti-prism.

Oxygen molecule is united by double covalence link. We have here on the second orbital shells of each atom electron octets in anti-prism tops (Figure 10 ). An example of "twisted" molecule with double covalence link serves the molecule of carbon dioxide (Figure 10).

Similar geometric models with square anti-prism structure (electron octets) and covalence links are typical for carbon compounds. Show, for example, saturated hydrocarbon with filled octet of the electronic shell - methane (Figure 11). Compounds, similar to carbon, of third period silicon element with four valency electrons on the following third electronic shell are also comfortable to present in the form of geometric models with square anti-prisms; with the only difference - in covalence links participate electrons of silicon third external electronic shell.

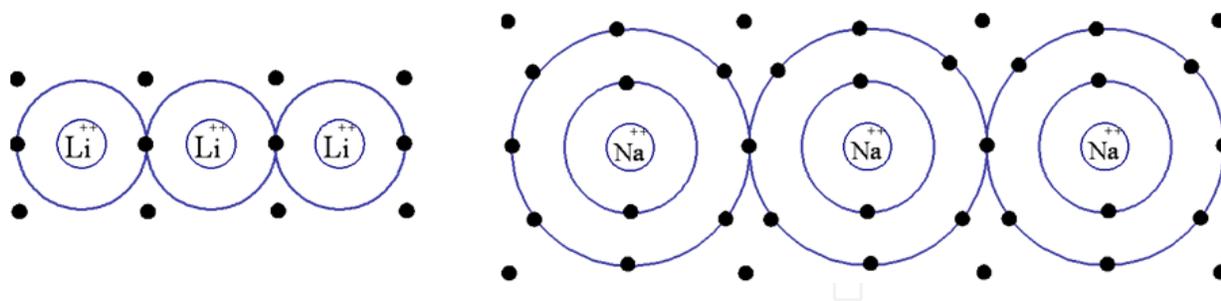
Within the framework of STEL model it is natural ("classical") way to represent models of hydrogen links, when on the first, nearest to proton (hydrogen ion) shell are stationary localized two electrons simultaneously belonging to two negative ions. For instance, hydrogen difluoride  $HF_2^-$  possesses linear structure  $F^-H^-F^-$ ; its steadiness is obliged to the proton linking two negative fluorine ions by Coulomb interaction (Figure11 ).



**Figure 11.** Structures for  $\text{CH}_4$  and  $\text{HF}_2$  molecules

The ionic link presents Coulomb ion interaction when external electrons of one atom complement more filled external shell of another atom. Here it is also comfortable for elements of second and third periods of the Table to consider electron octets of external shells with geometric approach in the form of anti-prisms. Typical examples serve sodium chloride and sulphureous magnesium.

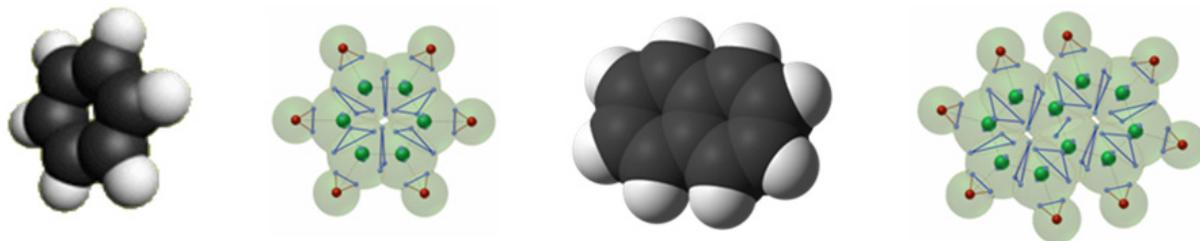
Now describe from used deterministic positions and STEL model metallic links when atom external shells are partly filled by electrons. Metallic links are realized through links of electronic shells nearest to the external shell, through one or several electrons, which begin to belong simultaneously to two nearby atoms. Then electrons of external blank shells and "spare" electrons of binding shell (if and when before links this shell was filled) become not connected with concrete atom and easy moving. Examples are schematic traditional 2D presentations of metallic electronic links for lithium and natrium (Figure 12). For nickel subsequent to the second filled electronic shell with 8 electrons octet follows the third shell with 16 electrons that is complemented up to 18 electrons by attaching nearby atom two electrons realizing metallic link.



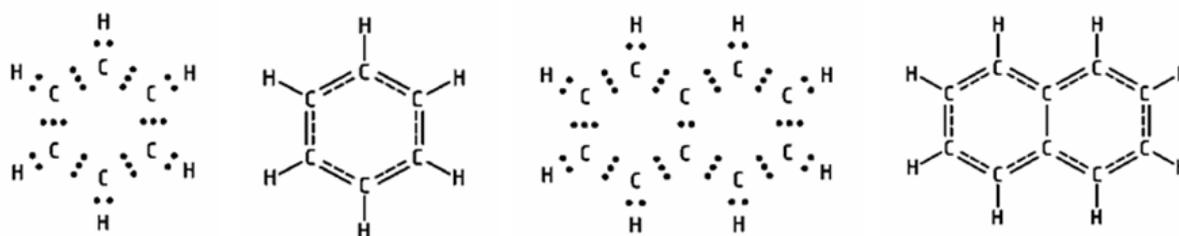
**Figure 12.** Schemes of metal linkages for Li and Na

Special consideration has fulfilled for hydrocarbon valence linkages in benzoyl  $\text{C}_6\text{H}_6$  and naphthalene  $\text{C}_{10}\text{H}_8$  molecules. We give the molecule images, their detail structures (Figure 13) and also electronic and structural formulas (Figure 14). It should be emphasized that the benzoyl ring has internal linkages between carbon atoms through three stationary electrons.

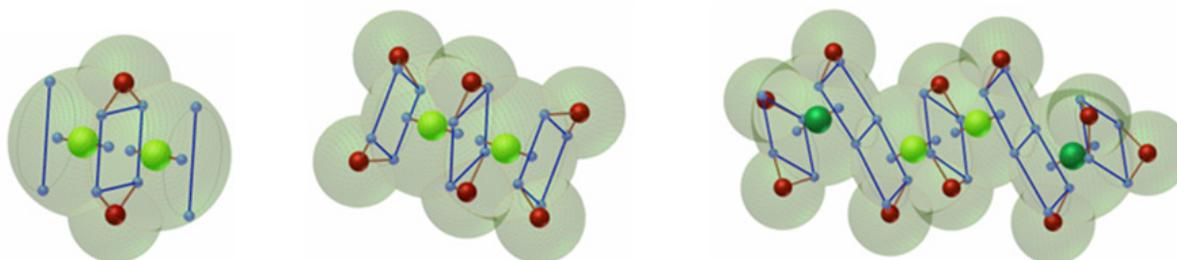
The next examples are related to borohydrogen molecules  $\text{B}_2\text{H}_2$ ,  $\text{B}_6\text{H}_6$ ,  $\text{B}_4\text{H}_{10}$  (Figure 15). The complex  $\text{B}_2\text{H}_2$  has special type of internal four electrons linkage and outer four valence linkages, similar the carbon and silicon atoms.



**Figure 13.** Benzoyl  $C_6H_6$  and naphthalene  $C_{10}H_8$  molecules and their form



**Figure 14.** Electronic and structural formulas of benzoyl  $C_6H_6$  and naphthalene  $C_{10}H_8$  molecules



**Figure 15.** Complex  $B_2 H_2$  and molecules  $B_2 H_6$  and  $B_4 H_{10}$

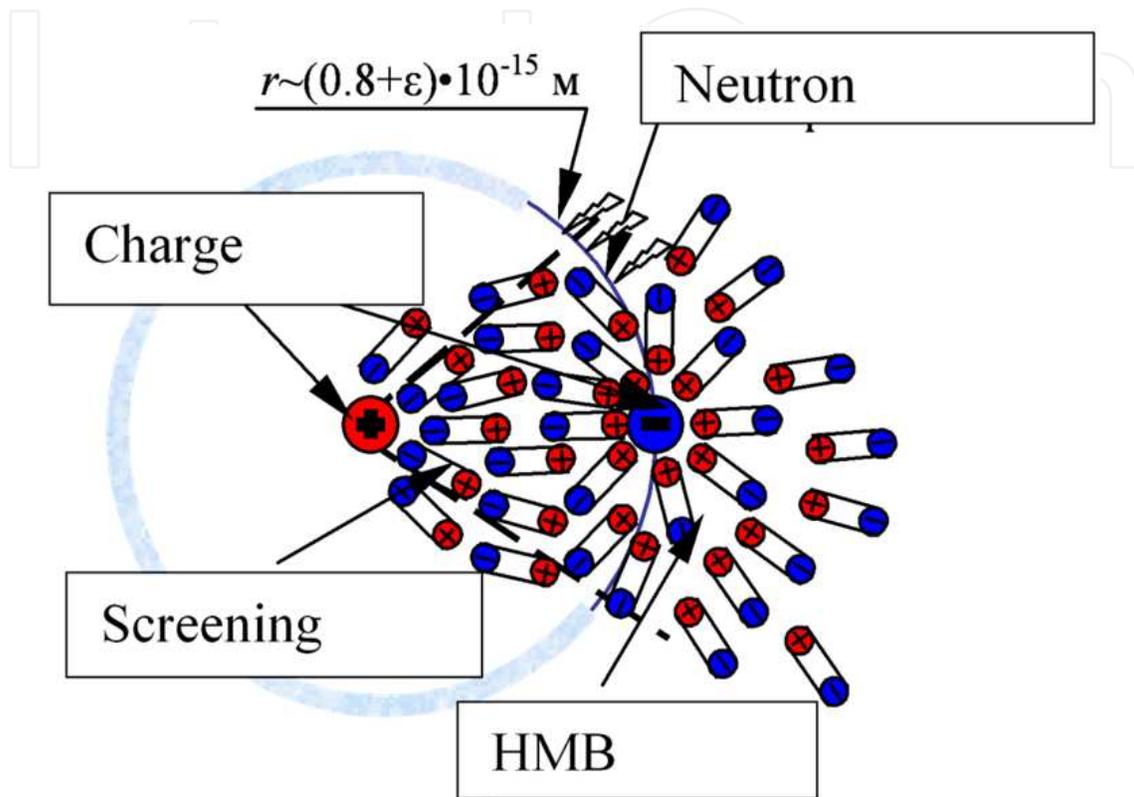
In the approach presented any molecular links are realized by stationary electrons of external orbits by means of electric (Coulomb) interaction with partial screening electron and nucleus "point" charges by DM polarized particles. Electric potential distribution is described in this approach by the same equation (4) with stationary electrons distribution providing minimum of total potential energy. The principle of minimum total potential energy brings about electrons stationary localization in geometric anti-prism tops that provides maximum repulsion of electrons on electronic shells. Anti-prism foundations turning are a base for shaping heliciform circuits of complex molecules (in particular, RNA and DNA molecules).

It follows to emphasize in the section conclusion that stated physical models allow looking from new positions at known ways of modeling chemical links. These methods may include the Lewis model and diagrams and Van der Waals sphere model for revealing intermolecular contacts.

#### 5.4. Examples of weak and strong interactions

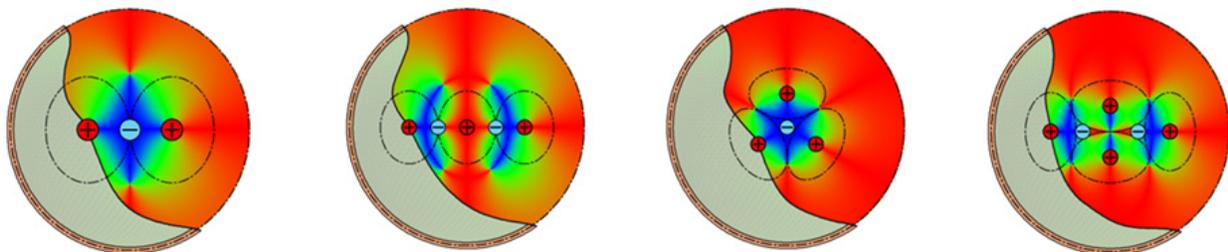
Following our methodology we show now shortly the scheme of neutron as a positive nuclear of proton with Debye screening (up to  $r_0=0.8 \cdot 10^{-15}m$ ) by liquid layer of HMB dipoles

and stationary electron, presenting on boundary of Debye region (Figure 16). Decay of neutron gives naturally proton, electron and antineutrino, which presents itself isolated soliton in DM gaseous medium. Exact soliton solutions for neutrino and antineutrino were obtained in papers [92-95].

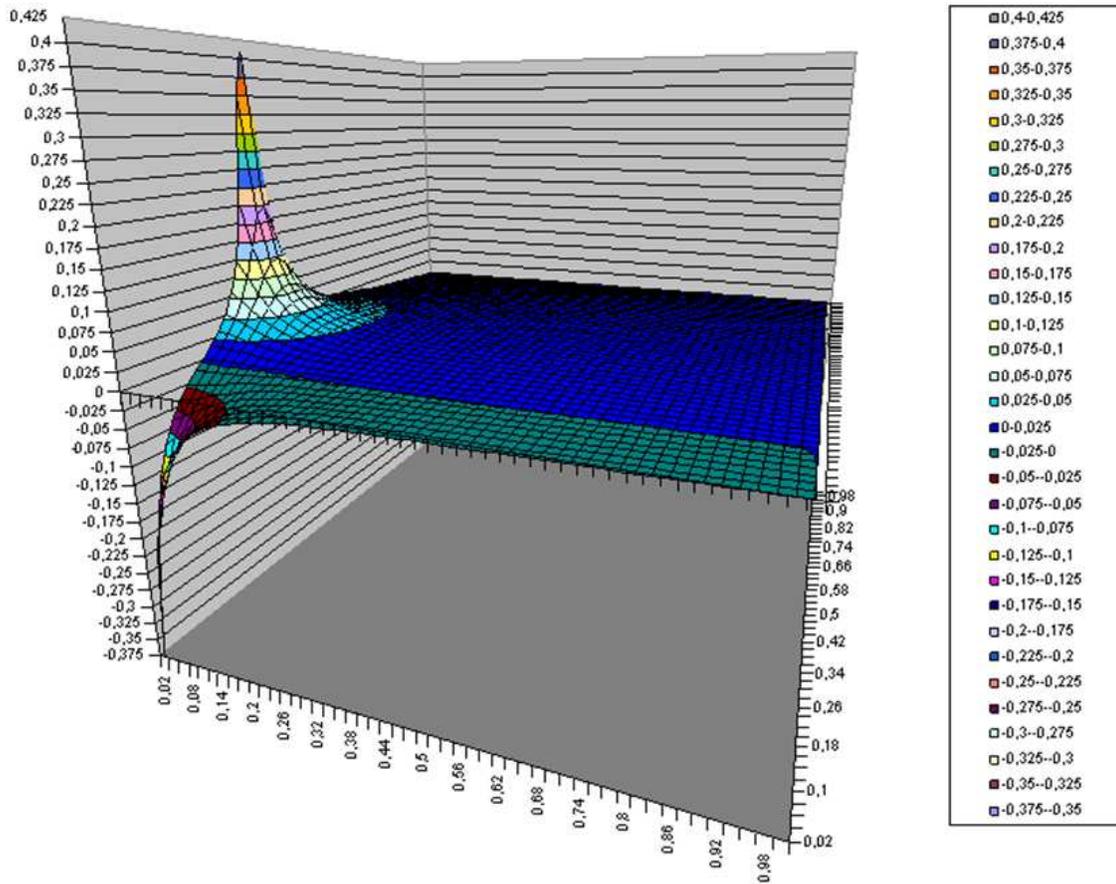


**Figure 16.** Scheme of neutron

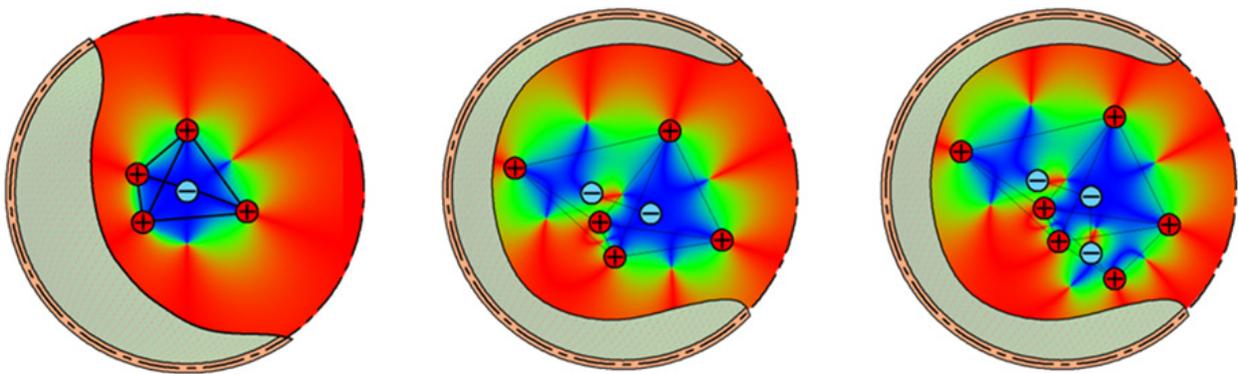
The STEL model with solution (4) allows us to simulate also an internal nuclear structure. Figure 17 shows the typical nuclear structures for deuterium, tritium, helium  $^3\text{He}$  and  $^4\text{He}$ . Potential distribution for deuterium was calculated (Figure 18). Figure 19 present the nuclear structure of  $^4\text{Li}$ ,  $^5\text{Li}$  and  $^6\text{Li}$ .



**Figure 17.** Internal structures of deuterium, tritium and helium  $^3\text{He}$  and  $^4\text{He}$



**Figure 18.** Numerical solution for potential distribution inside deuterium



**Figure 19.** Internal structures of Lithium  ${}^4\text{Li}$ ,  ${}^5\text{Li}$  and  ${}^6\text{Li}$

## 6. Additional experimental confirmations

*“Experience is and a source of knowledge and a criterion of truth.”.*  
Francis Bacon (1620)

In the last section of the chapter we would like to demonstrate additional experimental confirmations of our simulation and first of all the HMB (DM) medium presence in Cosmic space and on Earth. Here, as good examples, one can select wide experimental data on solid bodies, deoxyribonucleic acid (DNA) molecules, some aeronautics and astronautics.

## 6.1. Hooke's, Dulong–Petit's and thermal expansion laws

The solid body is characterized by structural rigidity and resistance to changes of shape or volume. The atoms in a solid are tightly bound to each other, either in a regular geometric lattice (crystalline solids) or irregularly (an amorphous solid). The forces between the atoms in a solid can take a variety of forms but today we take into account mainly electrostatic bonds. For example, a crystal of sodium chloride (common salt) is made up of ionic sodium and chlorine, which are held together by ionic bonds. In diamond or silicon, the atoms share electrons and form covalent bonds. In metals, electrons are shared in metallic bonding. Some solids, particularly most organic compounds, are held together with van der Waals forces resulting from the polarization of the electronic charge cloud on each molecule. The dissimilarities between the types of solid result from the differences between their bonding. New our item is the presence inside bodies (similar by containers) HMB (DM) medium with own pressure, which play the same important role also as electrostatic bonds and steady solid forms result by equilibrium between HMB medium pressure and electrostatic atomic forces.

**Hooke's law.** Hooke's law was found in 1610. The most commonly encountered form of this law is probably the spring equation, which relates the force exerted by a spring to the distance it is stretched by a spring constant  $k$ , measured in force per length

$F = -k\Delta x$ . The negative sign indicates that the force exerted by the spring is in direct opposition to the direction of displacement. It is called a "restoring force", as it tends to restore the system to equilibrium. In equilibrium state electrostatic forces and internal HMB medium pressure forces equal (the first equation in the system (3)). HMB pressure is increasing (or decreasing) proportional of displacement  $x$  (as for ideal gas case).

The potential energy stored in a spring is given by  $P_e = k\Delta x^2/2$ , which comes from adding up the energy it takes to incrementally compress the spring. That is, the integral of force over displacement. (Note that potential energy of a spring is always non-negative.) This energy is internal energy of HMB gaseous medium and also can be calculated using our gas dynamics modeling.

For HMB gaseous medium we have the state equation  $pV=NkT$ . When  $T=const$  and  $N=const$  the value  $pV=const$ . For the pressure increasing  $\Delta p$  with the change volume  $\Delta V=V(1-\Delta x/l)$  one can be written

$$(p+\Delta p)V(1-\Delta x/l)=NkT$$

and

$$\Delta p \approx \Delta x/l nkT.$$

Hence Young's modulus

$$E = \Delta p / \Delta x / l \approx nkT.$$

As an example we determine the concentration  $n$  on boundary polarized space for aluminum with  $E=70GPa$  and the Debye temperature  $T=394 K$

$$n \approx E/kT = 1.3 \oplus 10^{31} \text{ 1/m}^3.$$

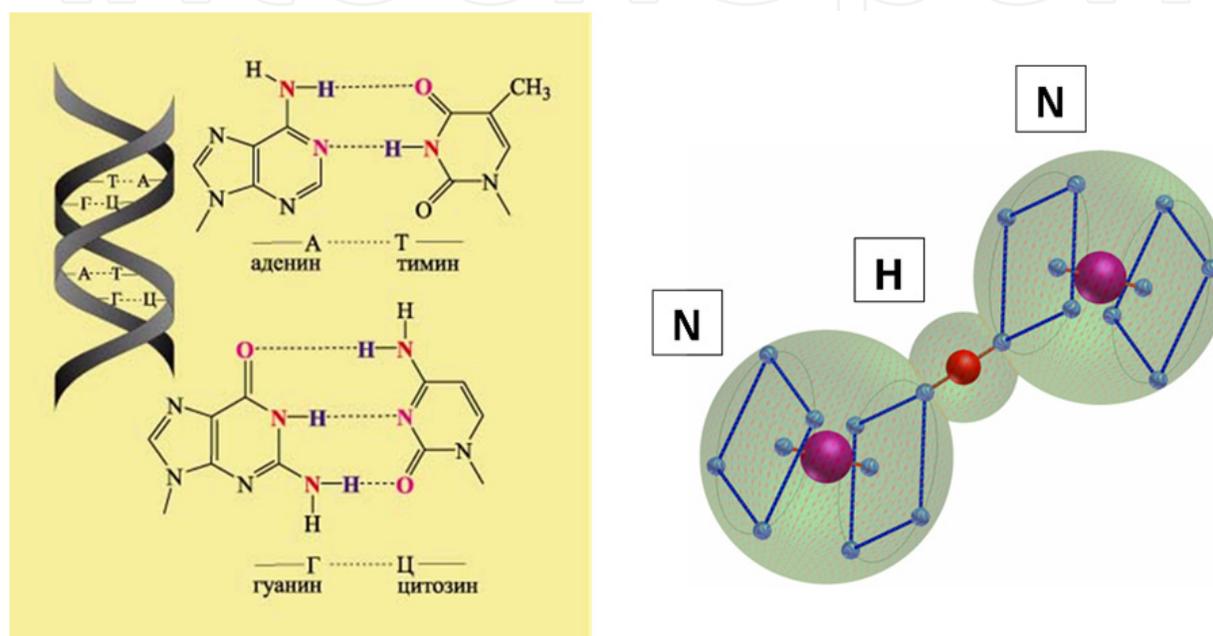
**Dulong–Petit’s law.** The Dulong–Petit law, a chemical law proposed in 1819 by French physicists P.L. Dulong and A.T. Petit, states the classical expression for the molar specific heat capacity of a crystal. Experimentally the two scientists had found that the heat capacity per weight (the mass-specific heat capacity) for a number of substances became close to a constant value, after it had been multiplied by number-ratio representing the presumed relative atomic weight of the substance. These atomic weights had shortly before been suggested by Dalton. In modern terms, Dulong and Petit found that the heat capacity of a mole of many solid substances is about  $3R$ , where  $R$  is the modern constant called the universal gas constant. Dulong and Petit were unaware of the relationship with  $R$ , since this constant had not yet been defined from the later kinetic theory of gases. The value of  $3R$  is about 25 joules per kelvin, and Dulong and Petit essentially found that this was the heat capacity of crystals, per mole of atoms they contained. HMB theory gives theoretical base for this law (see point 3.2 of the chapter).

**Thermal expansion law.** To a first approximation, the change in length measurements of an object ("linear dimension" as opposed to, e.g., volumetric dimension) due to thermal expansion is related to temperature change by a "linear expansion coefficient". It is the fractional change in length per degree of temperature change. The point 4.1 presents detail modeling of this law. Heat expansion of electronic shells (including external van der Waals spheres) on linear law is described by corresponding solutions change of equation (4) for polarized atom space when changing Debye radius  $D = (kT\varepsilon_0 / n_0 q^2)^{1/2} \sim T$  (since typical gaseous HMB concentration  $n_0$  at similar pressure  $p_0$  is inversely proportional to temperature  $T$ ). This law works well as long as the linear-expansion coefficient does not change much over the change in temperature.

## 6.2. Deoxyribonucleic acid “flash” memory

Deoxyribonucleic acid (DNA) is a nucleic acid containing the genetic instructions used in the development and functioning of all known living organisms. The DNA segments carrying this genetic information are called genes. Likewise, other DNA sequences have structural purposes, or are involved in regulating the use of this genetic information. Along with ribonucleic acid and proteins, DNA is one of the three major macromolecules that are essential for all known forms of life. DNA consists of two long polymers of simple units called nucleotides, with backbones made of sugars and phosphate groups joined by ester bonds. These two strands run in opposite directions to each other and are therefore anti-parallel. Attached to each sugar is one of four types of molecules called nucleobases (informally, *bases*). It is the sequence of these four nucleobases along the backbone that encodes information. This information is read using the genetic code, which specifies the sequence of the amino acids within proteins. The code is read by copying stretches of DNA into the related nucleic acid RNA in a process called transcription. Within DNA cells is organized into long structures called chromosomes. During cell division these chromosomes are duplicated in the process of DNA replication, providing each cell its own complete set of chromosomes.

Hydrogen bonds play an important role in maintaining two circuits of DNA molecule heliciform structure (Figure 20). This distribution provides minimal summary potential energy. The principle of minimal potential energy leads to stationary localization of electrons in antiprism vertexes (the point 4.3 of the chapter). The turn of antiprism bases lead serves as a basis for forming of spiral complex molecules (in this case DNA, RNA). Common polarized space of HMB medium in DNA molecule presents a base of “flash” memory. Figure 20 shows the polarized space for  $N\cdots H\cdots N$  bond. We can propose HMB is elementary bit of information for the development and functioning of living organisms.



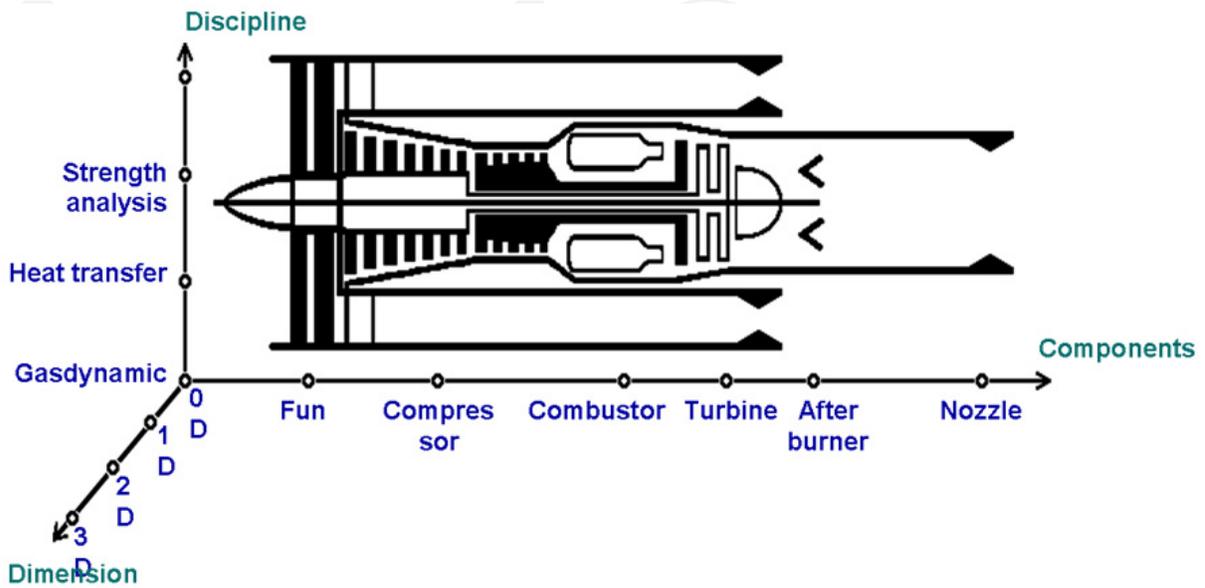
**Figure 20.** Hydrogen bonding  $N\cdots H\cdots N$  of DNA molecule

### 6.3. High temperature air breathing engine data

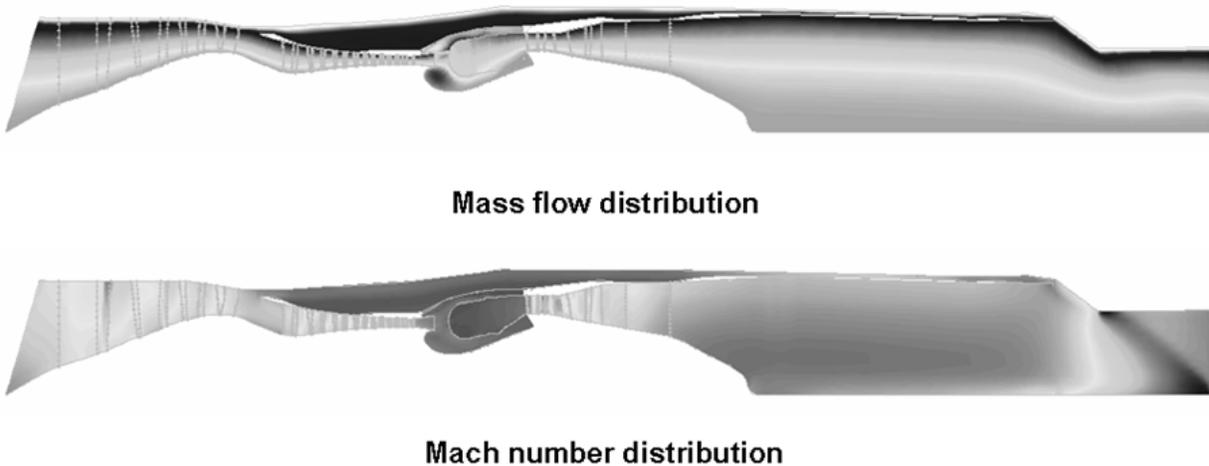
The united mathematical model (1) of the entire engine flow path is considered below (details present in [87, 88]). The typical flow passage of aviation gas turbine engine in meridional plane ( $z,r$ ) is shown in figure 21. The main parts of engine (here it is a turbojet bypass engine with afterburner) are: fan (low pressure compressor), high pressure compressor (with a few variable guide vanes), main angular combustor chamber, high pressure turbine, low pressure turbine, afterburner, secondary contour, variable-area nozzle. A simulation of working fluid (air or gas) moving is fulfilled in the whole flow of engine including core and bypass duct. We use in this case equation system (1) with thin layer viscous approaches and differential turbulence models.

Results of flow simulation for bypass gas turbine engine show on figure 22-24. The engine was investigated in detail experimentally. Both the whole engine and the core engine were tested. The experiments demonstrated significant discrepancy between the tested and design engine parameters for a number of working points. It became apparent first of all in

the decreased flow capacity of the compressor, and led finally to increased turbine inlet temperatures, decreasing thrust etc. Examples of compressor and turbine flows are shown on figure 23 and 24.

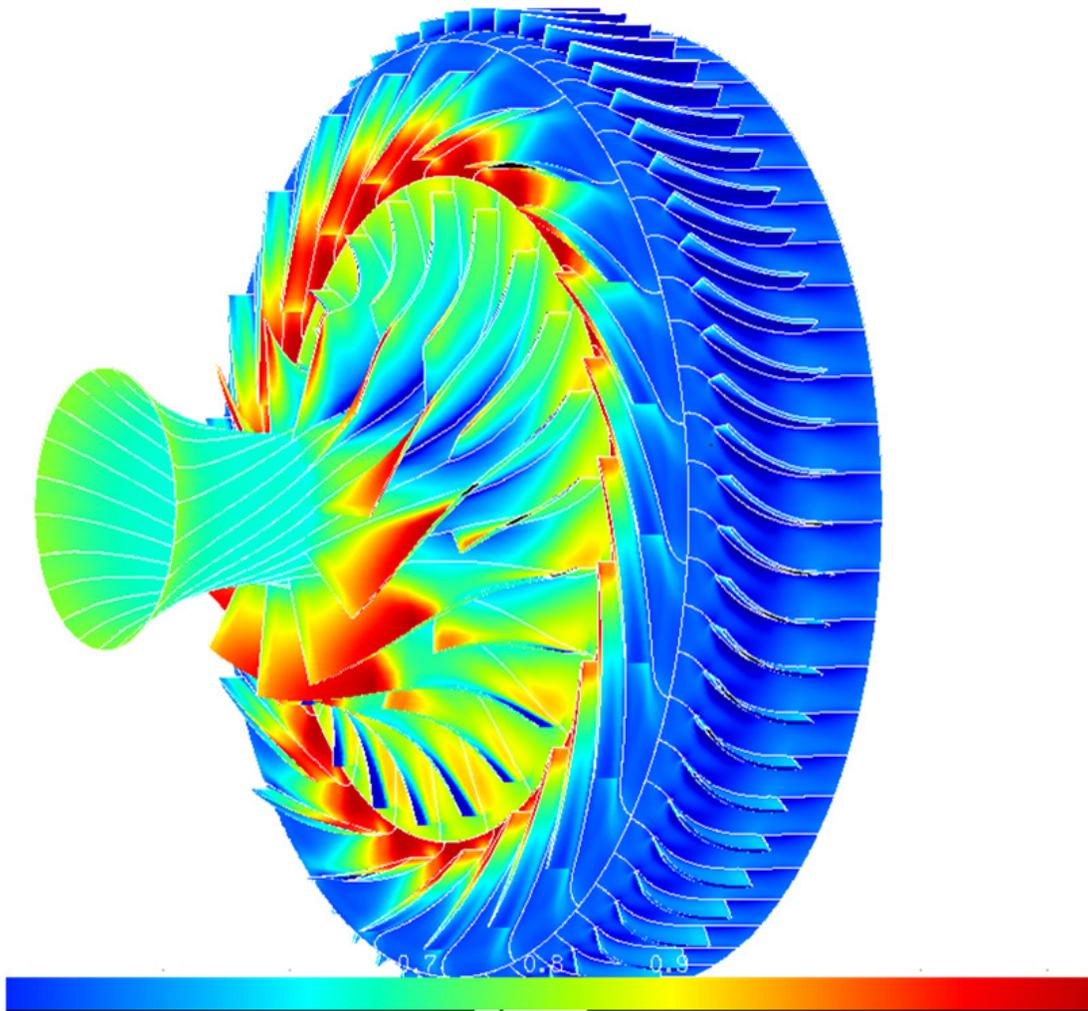


**Figure 21.** Air Breathing engine scheme (bypass turbojet)

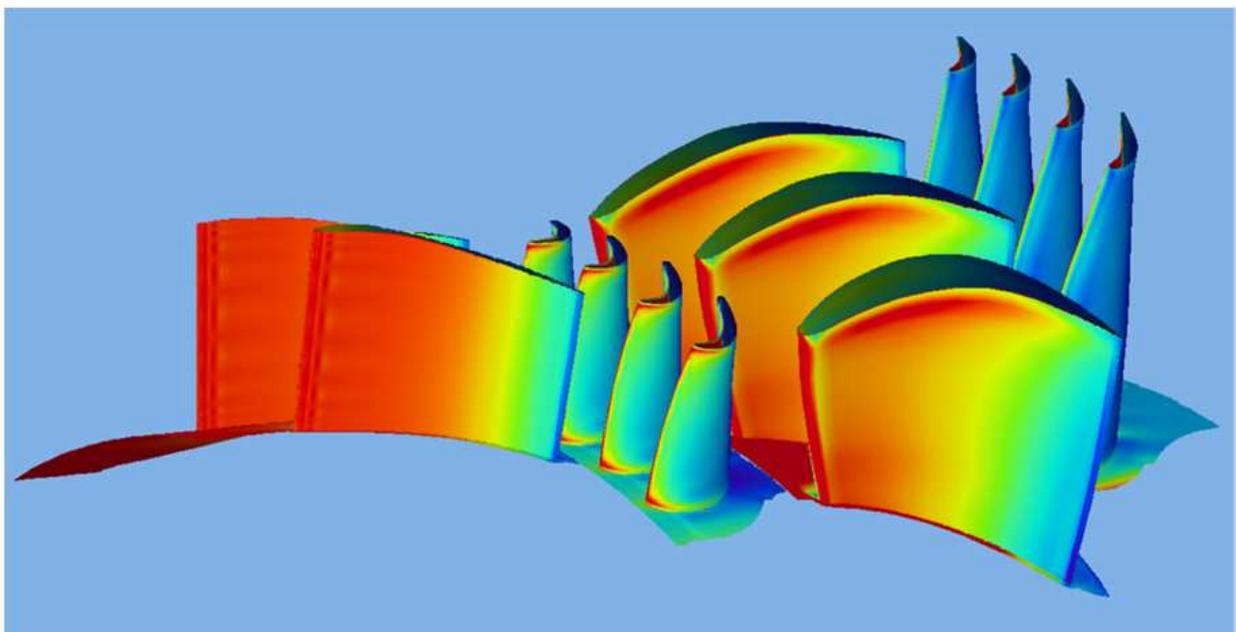


**Figure 22.** Examples of steady and unsteady calculations in turbojet engine

Channel flow with heat addition simulation is presented on figure 25. We can see temperature and pressure distributions inside channel and on up and down walls.



**Figure 23.** Static pressure distributions in the centrifugal compressor



**Figure 24.** Mach number contours in high pressure two stage turbine

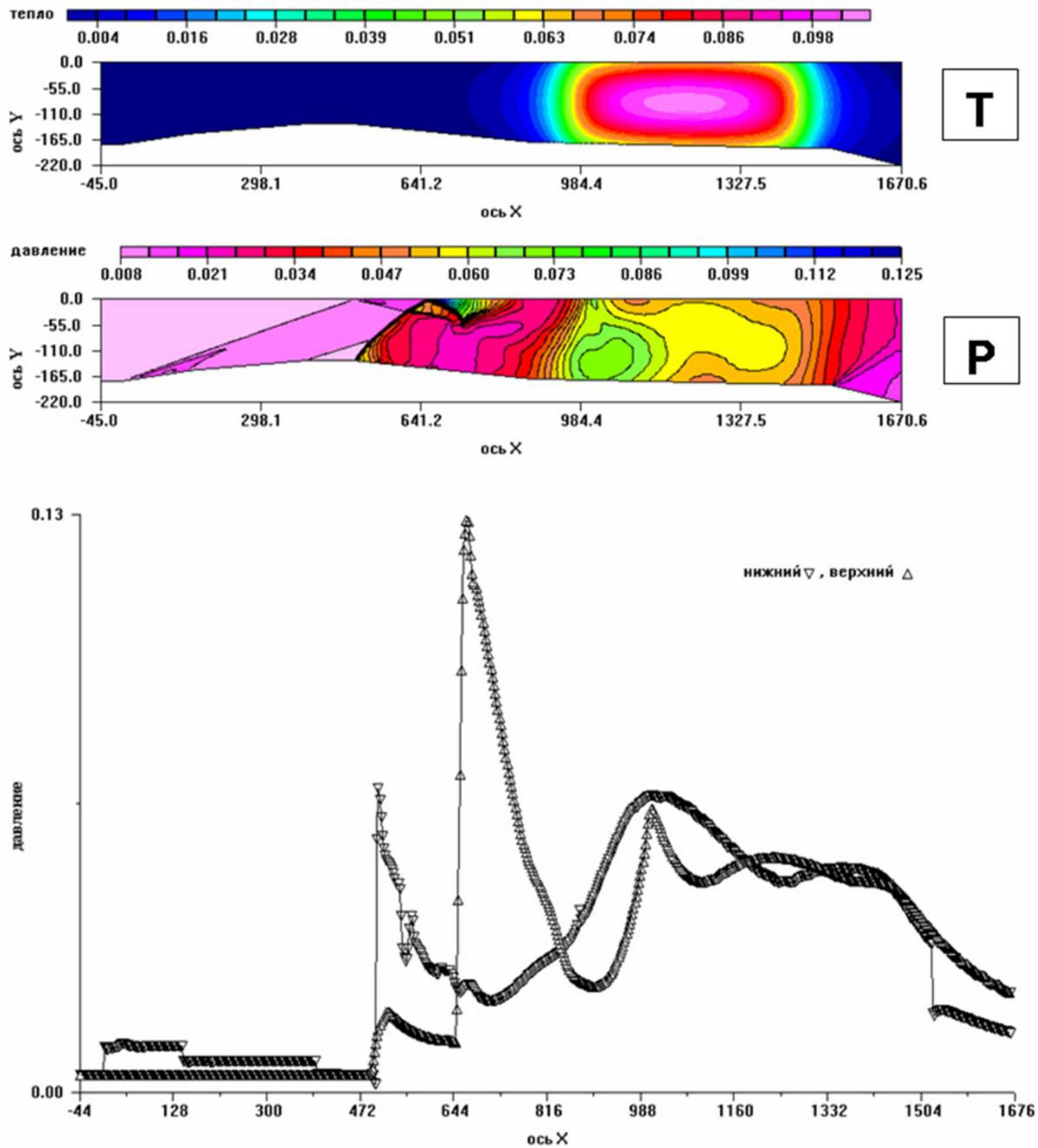


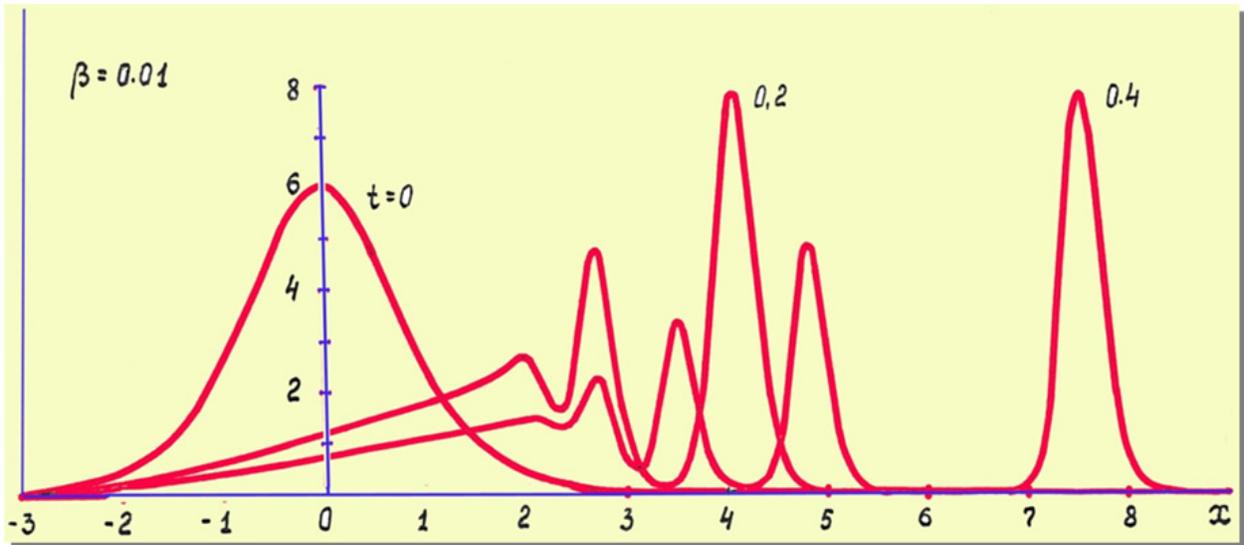
Figure 25. Pressure distributions in channel walls with intensive heat addition

### 6.4. Astrophysics examples

Let's demonstrate now possible application our modeling within the frame of classical mechanics approach for two astrophysics phenomena (gamma ray bursts and cosmic jets).

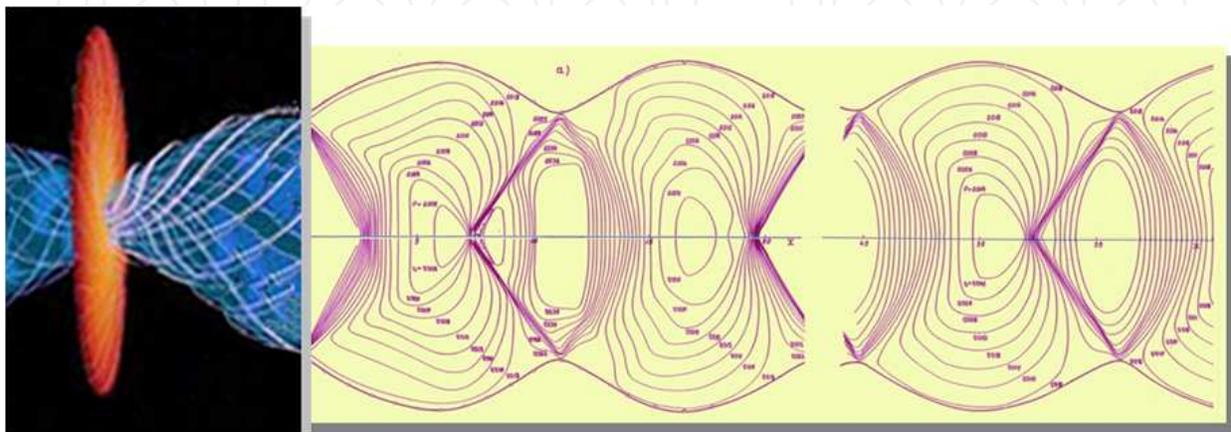
**Gamma ray bursts.** A good theoretic model of gamma-bursts can be represented by the above considered superluminal soliton solutions of rather big amplitude, which move in the dark matter medium without changing their shapes and loss of energy. We also give calculated solutions of the decomposition task of initial contraction for sequence of soliton

solutions (Figure 26). As a result of such decomposition a sequence solitons with decreasing amplitude and propagation velocity is formed. The similar solutions can simulate the effects of gamma-bursts after glowing, which later reaches an observer (with the delay of several years).



**Figure 26.** Gamma-ray burst and afterglow simulation

**Cosmic extragalactic jets.** Further using our modeling we can imagine a quasar center (of an active galaxy) like a jet engine combustion chamber form which in the born opposite directions and perpendicular to the galaxy disk the two supercritical jets are breaking out. The combustion processes of “sub baryon fuel” are going on in the quasar center at huge temperatures and pressures. Such a “sublimation” of dark holes seems more natural (than their quantum evaporation) and is well described from the standpoint of classical mechanics (obviously, an adequate definition of state equation is required). Figure 27 displays a scheme of an active galaxy with two superluminal jets flowing from its center in opposite directions. The calculation results (on equations (1)) of several “barrels” for such extragalactic jets are given (as constant pressure lines).



**Figure 27.** Natural jet engines with black hole combustor

## 7. Conclusion

1. Experimentally registries in the second half of XX century Cosmic Microwave Background (demonstrating the Space Energy presence) with temperature 2.725 K and Dark Matter are the background of the Grand Unified Theory (GUT) for nature laws and phenomena. The Hidden Mass Boson in classic dipole form gives a common base for Light and Dark Matter theory.
2. The GUT uses classic Newtonian mechanics, Euler's equations of motion (conservation laws of mass, momentum and energy), Maxwell's electrodynamics and Boltzmann's kinetic theory in absolute 3D Euclidean space with absolute positive direction time.
3. The GUT on the single position describes motion matter and antimatter, electromagnetic, weak and strong interactions and electrovalence linkages (atomic and molecule structures).
4. Additional empirical confirmations of the GUT are Hooke's, Dulong–Petit's, thermal expansion laws and interaction of radiation and matter. In the plane of practical applications the corrected theory of high temperature air breathing engines is demonstrated.

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